This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Agric. Dept.

Main Lib.
Agric. Dept.

LIBRARY
OF THE
UNIVERSITY OF CALIFORNIA.

Class AGRIC. LIBRARY

AGRICULTURAL
LIBRARY,
UNIVERSITY
—OF—
CALIFORNIA.

STATE AGRICULTURAL COLLEGE

Fort Collins, Colorado

COLORADO AGRICULTURAL EXPERIMENT STATION

PUBLICATIONS OF 1908.

AGRIC. LIBRARY

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President	Canon City,	1911
HON E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS	Colorado Springs,	1915
HON. J. L. BRUSH	Greeley,	1915
GOVERNOR HENRY A. BUCHTEL, PRESIDENT BARTON O. AYLESWORTH, *Ex-Officio*		
A. M. HAWLEY, *Secretary.*	CHARLES SHELDON, *Treasurer*	

EXECUTIVE COMMITTEE IN CHARGE

B. F. ROCKAFELLOW, *Chairman.* A. A. EDWARDS

B U. DYE

STATION STAFF

L. G. CARPENTER, M. S., *Director*	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., Ph D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.*	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
——†—	AGRICULTURIST
W. H. OLIN, M. S.*	AGRONOMIST
W. G. SACKETT, B. S.**	BACTERIOLOGIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOGULAS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S.,	ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S.,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS
MIRIAM A. PALMER	ARTIST
L. C. BRAGG,	ASSISTANT IN ENTOMOLOGY

STATE FRUIT INVESTIGATIONS.

O. B. WHIPPLE, B. S., GRAND JUNCTION	FIELD HORTICULTURIST
GEORGE P. WELDON, B. S., DELTA***	FIELD ENTOMOLOGIST

OFFICERS

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

* To October 19, 1908.
**From May 1, 1908.
† To be filled.
*** From March 1, 1908.

PUBLICATIONS OF 1908

BULLETINS

No.

126—"Cantaloupe Breeding." ---- By P. K. Blinn

127—"Climate of Colorado, Temperature, 21 Years' Record at Fort Collins." ---By L. G. Carpenter and R. E. Trimble

128—"Alfalfa Studies, Progress Report." ---- ---- By P. K. Blinn

129—"Extraction of Beeswax." ---- ---- ---- ---- By F. C. Alford

130—"The Evergreen Trees of Colorado." ---- By B. O. Longyear

131—"Arsenical Poisoning of Fruit Trees." --By Wm. P. Headden

132—"Destruction of Concrete by Alkali." --By Wm. P. Headden

133—"A Few Orchard Plant Lice." ---- ---- ---- ----

Bulletin 126 January 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CANTALOUPE BREEDING

BY

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

P. K. BLINN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915
GOVERNOR HENRY A. BUCHTEL, } *Ex-Officio.*		
PRESIDENT BARTON O. AYLESWORTH, }		

A. M. HAWLEY, SECRETARY — CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*,	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.,	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
W. H. OLIN, M. S.,	AGRONOMIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOUGLASS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S.,	ASSISTANT ENTOMOLOGIST
B O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS
STATE FRUIT INVESTIGATIONS	
O. B. WHIPPLE, B. S., GRAND JUNCTION,	FIELD HORTICULTURIST
GEORGE P. WELDON,* B. S., DELTA	FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

*After March, 1908

CANTALOUPE BREEDING

PHILO K. BLINN

The cantaloupe industry has made its principal development since the introduction of the Netted Gem variety; for due to its small uniform size and good carrying quality the growth of the industry has been possible.

It was not until the excellent quality of the cantaloupes produced on irrigated land under dry climatic conditions was realized, that the industry became prominent.

The first cantaloupes on the eastern markets from the arid region were shipped from Rocky Ford, Colorado, in 1896. Their superior flavor was an innovation to the eastern melon trade; the contrast in quality was so striking as compared to the eastern and southern products that the Rocky Fords at once became regarded as a new variety, and under that popular symbol have won a national reputation. Each year thousands of cars of cantaloupes are marketed as genuine Rocky Fords, but from widely distant fields; those from the southern states appearing on the markets early in May, and continuing the supply from various states until late in October.

The phenomenal growth of the industry and the great demand, has established the cantaloupe as one of the favorite fruits of the American table; if the quality could always be assured there is hardly a fruit that could rival it in popularity or price.

Some of the causes that lead to poor quality are: Unfavorable climatic conditions, plant diseases, insect injuries, glutted markets and the unavoidable delays in transportation; many of which are beyond any apparent means of control. Yet when we consider what has been accomplished by plant breeding in other lines, it does not seem impossible that there could be developed a disease-resistant cantaloupe that would possess such superior qualities as to enable it to endure adverse conditions and still reach the markets in better state and with higher flavor than any we now possess. To this end cantaloupe breeding becomes an important feature of the industry, for at best the crop is a hazardous one, due to the above named influences and until recently careful seed selection has been generally neglected.

A GOOD DEMAND FOR GOOD SEED.

The general growth of the industry has created a large demand for cantaloupe seed, and naturally Rocky Ford has been an important source of supply. It seems that it is more than the notoriety of the name that gives an intrinsic value to the seed produced

at this point, for the cantaloupe growers of California and the southern states look to Rocky Ford each year for their supply of seed. They unanimously concede that they can mature their melons a week to ten days earlier and be assured of more uniform results in regard to size and quality, when they plant the Colorado grown seed, than if they use the same strain after it has been grown native with them a year or so. It is a good instance of the change in plants, that environments may sometimes produce, and how these variations may be transmitted to a degree, when the plants are grown under other conditions. The effects of altitude and latitude have long been regarded as an influence that hastens maturity in plants when their seed are grown in lower or southern regions. It is also a notable fact that grains produced in the dry climatic conditions of Colorado are heavier per bushel and are superior in quality to that grown in humid sections where the rainfall is excessive; it is evident, that where the moisture is controlled, and the soil and weather conditions will develop the fine flavor and qualities found in the Rocky Ford cantaloupe, that the same conditions will, in a measure, lend an influence to mature the seed with superior germinating power, vigor of growth and strong inherent tendencies, over that produced in less favored localities. This would indicate that points in Colorado are destined to continue as superior cantaloupe seed growing centers, provided the growers will resort to the proper methods of seed breeding that will insure the improvement of the cantaloupe in all its possibilities.

INDEFINITE AND UNSYSTEMATIC SELECTION.

Those familiar with the subject realize that a large amount of the seed that has been saved in the past was not choice selected seed, for much of it is saved from cantaloupes that were unmarketable for some reason, or it was saved late in the season from immature melons after frost has destroyed the vines; improvement under such conditions would hardly be expected and deterioration would be almost inevitable. However, there are growers who have been interested in producing choice cantaloupe seed, but even at best their system of selection has been too indefinite and incomplete to insure the best results. The plan of most growers in selecting seed for their own planting, is to lay aside the choicest specimens from the piles as they are gathered for market; these may be further graded before they are finally saved for seed, which would seem that the system possessed some merit, yet it is quite analogous to the use of the fanning mill for developing improved grain, or the selection of seed corn from the crib to better the corn crop; the selection is incomplete, for the seed selected from an indiscriminate pile does not take into consideration the many inherent tendencies of the plant from which it was produced, no matter how

perfect the specimens may chance to be; another serious weakness is the lack of adherence to a definite outline of the qualities that should be embodied in a perfect cantaloupe.

The different ideals of selection have given rise to numerous strains of the Rocky Ford cantaloupes, which are simply the Netted Gem variety developed under different conceptions of type and quality; there may be the element of cross-fertilization in the origin of some of the strains yet the foundation stock of all was originally the same strain, and the general characteristics of this variety has constituted the principal lines that have been considered in the selection of the Rocky Ford seed. For example, the uniformity of size and the netting are points that have been considered and are well developed in several strains; yet equally essential are the inherent traits of the plant and the quality of the fruit. For example, early, prolific production and disease resistance are of prime consideration as well as a thick, fine flesh of rich flavor with no disagreeable consistency or after tastes which are all qualities that should be embodied in a perfect cantaloupe.

Doubtless the acme of perfection may never be realized, for some of the points may be antagonistic attributes, and the laws of plant breeding are not so well defined as to enable one to outline a scheme for seed selection that will insure the desired results in a given time.

AN EXPERIMENT TO IMPROVE CANTALOUPES.

The object of this article is with a view of outlining the methods and results of a definite investigation along this line, presenting the facts that have grown out of this work in such a way as to serve the future efforts in cantaloupe breeding.

The Colorado Experiment Station, in 1903, instituted an investigation to develop if possible, a cantaloupe that would be immune to the attacks of the fungus disease, commonly known as "melon rust" or "blight," which is a serious menace to the melon industry. The first effort was a study of the cantaloupe fields to ascertain if any resistant tendency existed in the various strains of the Rocky Ford cantaloupes.

Owing to the different soil and the cultural conditions of the different farms, it was impossible to draw conclusions, as all fields were affected to some extent and eventually all succumb to the disease.

It was evident that a comparative test under more uniform conditions would be necessary to determine the point in question. Accordingly the following season the principal strains of the Rocky Ford cantaloupes were tested in comparison on a piece of ground that had been seriously affected with the fungus. The plat was uniform in condition and had the same care in all respects, yet the

results of the test revealed that one of the strains had marked disease resistant qualities, for when the balance of the plat was practically dead and dried up with the disease the rows of this variety had a number of plants only slightly affected.

The seed of these resistant individuals were secured and the following season, 1905, the same plat of ground was again used, in order that the rust-resistant feature could be developed in as adverse conditions as possible. It chanced this season that one of the rows in the plat was planted with the seed of one cantaloupe and the product of this row was so uniform in all of its qualities that it was evident that individual selection was an essential point to consider; also the increased percent of the resistant plants gave evidence that the quality was transmitted and could be developed by seed selection.

The seed of the most resistant plants were again saved, but this time each one was kept separate, the next year, 1906, the same plat was again used. The test demonstrated that the product of some plants reproduced quite uniformly and in others there was a tendency to vary; this seemed to emphasize the importance of selecting individual melons as well as the plant, and isolating the breeding plats as far as possible to prevent undesirable crosses. One row in the plat was planted as a check row, with the seed of a very choice melon but which had not been selected for the disease-resistant quality. This row was destroyed with the rust at least two weeks before the balance of the plat gave signs of the disease to any extent. (Plate I)

As the disease began to develop in the plat, a careful study was made and the most resistant plants were numbered by a stake, and as the melons ripened the most desirable were selected and the seed saved separate with a descriptive record made of each. Near the close of the season the plat was gone over again and noted as to which plants had been the most resistant during the summer; this revealed the fact that a few had been more enduring than all the rest. The seed of these could be easily identified and those that scored the highest in points of quality, were selected for the work in 1907. The seed were planted in separate adjacent blocks of fifty hills each on the same old plat that now, for five consecutive years had been devoted to cantaloupes, which is enough to insure a failure on account of the disease with any of the ordinary strains of seed after it has been grown on the same soil so long; but since the beginning of the resistant selection the plat has shown a decrease in the presence of the disease, while in adjacent fields the fungus has been as prevalent as ever and even more destructive. Except for a few individual plants, the plat during the past season has been practically free from the disease.

PLATE I.

1. A VINE RUSTED ON CHECK ROW
2. ADJACENT VINE SHOWING RESITANCE TO RUST

PLATE II.

1. BUD 24 HOURS BEFORE OPENING
2. BUD EMASCULATED
3. BLOOM JUST OPENED
4. CALYX AND COROLLA REMOVED, SHOWING 3 ANTHERS ATTACHED
5. SET DEVELOPING

PLATE III.

EXTERNAL POINT OF NETTING AND SIZE

LIBRARY
OF THE
UNIVERSITY
OF

PLATE IV

CONTRASTS IN INTERNAL QUALITIES
NO. 2—PERFECT TYPE

PRACTICAL TESTS OF THE RESISTANT STRAIN.

Several tests of the rust-resistant strain were made with commercial growers in the vicinity of Rocky Ford, and all the reports have been of a flattering nature. Similar tests were also made in Illinois and Indiana through the co-operation of the Experiment Stations in those states, and the following copies of letters are the reports sent in.

From C. G. Woodbury, Assistant Horticulturist of the Agricultural Experiment Station, Purdue University, Lafayette, Indiana, under date of August 30, 1907:

"You remember that you forwarded me some seed early last spring, of your new strain of the rust-resistant Rocky Ford melon. I placed this out in several localities in Southern Indiana, where the rust is usually prevalent, and am very pleased to report that your strain has proven to be nearly immune; in one place where there was a small patch directly across the road from a field which the rust ruined entirely, the vines from your seed showed no effects of the disease whatever. To test the matter as severely as possible I had badly affected runners from the field that was dying of the rust cut off and scattered among the plants of the rust-resistant strain; even then they became affected only slightly.

"No doubt before this you have had a visit with Professor Orton of the Department of Agriculture, and he is able to corroborate my statements, since I had the pleasure of visiting some of the fields with him in Southern Indiana a short time ago."

From John W. Lloyd, of the University of Illinois Agricultural Experiment Station, Urbana, Ill., October 2, 1907:

"The melon seed you so kindly sent me last spring exceeded my highest expectations in reference to rust-resistance under Illinois conditions. I distributed the seed among a number of the commercial growers located at different points. Many growers lost or failed to plant the seed or did not secure a stand, but with all who succeeded in growing a crop the results were the same: The vines remained green and vigorous after other melons were dead from the rust; the melons netted exceedingly well and were fine flavored. The only objection raised against the melon was its late maturity; in some cases the entire crop from other varieties had been marketed before any ripe specimens of the rust-resistant could be found. It is true that the maturity of the other varieties was hastened by the rust.

"I believe this melon will be exceptionally valuable for extending the season after other varities are gone. However, in our experimental plat where the other varieties were protected by spraying and the rust-resistant plants left unsprayed, there was not so much difference in the time of ripening, though the rust-resistant were somewhat later. Toward the end of the season the unsprayed rust-resistant vines were in better condition than the sprayed vines of the other variety.

"The small lot of exceptionally select seed which you sent was planted by itself at a distance from other melons, and the plants thinned to one in a hill. There was considerable difference in the rust-resistance of different plants, and I have saved seed from some of the most resistant with a view of planting each separately, and making further selection next year."

The results of the investigation have demonstrated the possibility of controlling, to some extent at least, the injuries from the "rust" fungus by systematic seed selection and breeding.

VARIATIONS OF INDIVIDUAL SELECTIONS.

The seed of eighty choice individual cantaloupes of the rust-resistant strain were planted, on alfalfa sod, in blocks of twenty-five hills each, under as uniform conditions as possible. The object of this test was to determine the efficiency of the disease resistance on soil less affected with the fungus, and to study the problems of individual variation from individual selections, with a view of improving other characters in the Rocky Ford cantaloupe.

The test did not reveal any greater disease resistance by virtue of the alfalfa sod, but a marked contrast in the degree of resistance was revealed in the plats of different individual selections.

The variations of some of the plats made it easy to distinguish their outlines after the vines had run together and completely covered the ground in the field. The seed was all of the same variety and had been carefully selected for several years, and was considered a pure strain.

Had the seed been jumbled together and planted as usual, the contrast and variations of the different selections would not have appeared to attract attention, but by planting each separately it was evident that it makes a vast difference in results which one was chosen for seed, even from a number of seemingly choice specimens.

The first contrast noted was the variation in the germination of the plats, which ranged from forty to one hundred percent and was clearly the result of vitality in the selections, the date of first setting fruit varied eight to ten days in different plats without apparent reason, and the time of ripening of some of the plats was prolonged to nearly three weeks, though this difference may have been partly due to the premature ripening of some of the plats most affected with the fungus, and as the most rust resistant selections were usually the latest maturing plats, yet it was clear from the early setting and development of the plats before the disease was manifest, that some of the plats were much earlier than others. There were also various combinations of the different qualities in the different plats; for instance, the rust-resistant feature was associated with excellent melons in regard to netting, form and size, in some plats, while in others the qualities were inferior in this respect.

When the pedigrees were traced a general uniformity prevailed in the plats whose seed had a common parentage a year or two previous, yet irregularities were constantly appearing in the products of some of the selections, and also the tendency to breed true seemed equally characteristic of others. In one instance the color of the flesh and the solidly filled seed cavity was uniformly reproduced for four succeeding years.

The variations of the individual selections seemed to come from no other reason than the inherent tendency of the individual, for the whole plat had the same care in every respect possible.

The recent application of Mendel's laws of heredity offers an explanation of the results observed in this experiment. The heterozygous unit factors of some of the selections produced the irregular variations, while the homozygous, or pure unit factors of others, resulted in characters breeding true.

HYBRIDIZATION.

So far in the investigation we have employed only seed selection to secure the desired results; but now the need of hybridization is manifest to combine the desired qualities found in different selections, for simple seed selection has been inadequate to this object. To combine the rust-resistance with earlier maturity is much desired, and to this end observations and tests have been made during the past season to ascertain the fact and methods necessary for artificial cross-fertilization of the cantaloupe flowers. As a result several cross-pollenizations were made between some of the best selections of the rust-resistant strain and an abnormal early setting plant of another strain known as the "Watters." According to Mendels law of constant proportitions resulting from such hybrids, we may confidently expect the desired combination if the qualities are compatible.

It was found by observations that the flower of the Rocky Ford cantaloupe is quite the exception to most of the cucurbitaceous plants like the cucumber and many other varieties of melons, which have their stamens and pistils borne in separate flowers, while the Rocky Ford variety is hermaphroditic, that is the stamens and pistil are produced in one flower. It also has purely staminate flowers produced in great profusion at the intersection of nearly every branch.

It is evident that cross-fertilization is readily possible, yet the arrangement of the flower and the results of observation would indicate that self-pollenization is quite as common or more so.

The numerical arrangement of the flower was found to vary, the three-lobed pistil with three stamens was the common form, but four and even five were encountered. The result of a three-lobed pistil is shown in No. 1 in Plate IV.

METHODS OF ARTIFICIAL FERTILIZATION.

The pollen of the cantaloupe flower has been found to ripen about the time the flower is opened and the pollen is usually shed at this time, which is usually early in the morning; to fertilize the flower and have the results of known origin, it is necessary to find the bud about twenty-four hours before it opens (Plate II,

No. I), which can easily be told by observation; in this stage it should be emasculated, before the pollen lobes are ripe. By cutting around the base of the corolla and calyx, the two may be removed with the stamens attached, leaving the pistil free and exposed. (Plate II, No. II and IV.) A small paper sack is then tied over the stem to protect the pistil from foriegn pollen until the following morning, when the stigma will be at about the same stage, as if the flower had not been disturbed, and ready to receive the pollen.

The desired pollen is introduced from a fresh opened flower, by pulling off the corolla the stamens are exposed, showing the ripe pollen grains which are transfered by touching the ripe pollen lobes to the pistil or stigma until it is well covered with the yellow pollen grains. The paper sack is then replaced for several days until development begins.

SUMMARY.

The general conclusion of the investigation is that systematic seed breeding will intensify any desired qualities found in cantaloupes, as well as in corn and other crops.

The essential points for breeding cantaloupes are:

1. Keeping records that will establish the history of a plant at any time.
2. Close observation to detect desirable variations.
3. Individual selections.
4. Comparative testing to determine relative merits.
5. Judging the average results of a selection rather than the behavior of an individual in it.
6. An understanding of physiological botany, in order to perform successfully cross-pollenization when necessary.

The principal points, or unit characters to consider, might be enumerated as follows:

1. Germinating vitality. 2. Vigor of growth. 3. Early setting. 4. Quick maturity. 5. Prolific yields. 6. Uniformity of the desired qualities in the product.

The standard for the Rocky Ford Cantaloupe of today might be given to include the following qualities:

1. Proper size to pack in the standard crate.
2. Fine, heavy, light grey netting, covering the entire melon. Plate 3.
3. Color character of the background or interstices between the netting, such as will indicate to the eye, by a slight change of tint, when the cantaloupe is ready to pick, which is rather an olive green, and one that does not turn yellow fast.
4. A thick flesh and solid filled seed cavity. (Plate 4, No. 2.)
5. A firm, smooth texture, fine grained and free from any fiber or water-core.
6. A green colored flesh is usually preferred, though commonly it is combined with orange or salmon tint.
7. The flavor is the ultimate test; it should be rich, sweet and spicy, free from any disagreeable consistency or after tastes.

If the same care and attention was paid to the breeding and growing of improved cantaloupes, or other crops, there would be a great demand for pedigreed seed, as well as the call for registered horses, sheep or cattle.

Bulletin 127 January, 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

CLIMATE OF COLORADO

TEMPERATURE

21 Years' Record at Fort Collins

BY

L. G. CARPENTER

and

R. E. TRIMBLE

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915
GOVERNOR HENRY A. BUCHTEL, PRESIDENT BARTON O. AYLESWORTH,	*Ex-Officio.*	

A. M. HAWLEY, SECRETARY — CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*, — IRRIGATION ENGINEER
C. P. GILLETTE, M. S., — ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D., — CHEMIST
WENDELL PADDOCK, M. S., — HORTICULTURIST
W. L. CARLYLE, M. S., — AGRICULTURIST
G. H. GLOVER, M. S., D. V. M., — VETERINARIAN
W. H. OLIN, M. S., — AGRONOMIST
R. E. TRIMBLE, B. S., — ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S., — ASSISTANT CHEMIST
EARL DOUGLASS, M. S., — ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S., — ASSISTANT ENTOMOLOGIST
B O. LONGYEAR, B. S., — ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S., — ASSISTANT IRRIGATION ENGINEER
F. KNORR, — ASSISTANT AGRONOMIST
P. K. BLINN, B. S., — FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S., — POTATO INVESTIGATIONS

STATE FRUIT INVESTIGATIONS

O. B. WHIPPLE, B. S., GRAND JUNCTION, — FIELD HORTICULTURIST
GEORGE P. WELDON,* B. S., DELTA — FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S., — DIRECTOR
A. M. HAWLEY, — SECRETARY
MARGARET MURRAY, — CLERK

*After March, 1908

TEMPERATURE AT FORT COLLINS

21 YEARS' RECORD

Graphical Diagrams of the Normal Daily Temperature and the Highest and Lowest Daily Average

By L. G. CARPENTER *and* R. E. TRIMBLE

The Meteorological records for Fort Collins have been continued under essentially the same system for 20 years. Observations were made tri-daily up to July 1, 1889, when we changed to the twice daily records.

The average temperature which forms the basis of these charts is the mean of the maximum and minimum temperatures of the dav. The observations have been made by several different persons, but since 1891 have been made by Mr. R. E. Trimble.

The instrument house has been under substantially the same conditions, but moved several times for short distances. It has been of the Standard Weather Bureau type, a louvre-sided instrument house, with the floor about 6 feet above a grassy plot.

The dotted line of the diagrams shows the average temperature for every calendar day during the year. It is the average of 20 years, 1887-1906 inclusive.

The highest daily average during the 20 years is indicated by the upper line, and the lowest daily average by the lower line. Thus the warmest first of January in the 20 years averaged 39°, and the coldest -4°. The diagrams do not show the minimum temperature nor the maximum. The average range for January is 28°, and for August 33°. The range on the days of extreme temperature is much greater, often 40° or even 55°, so that if one selects the portion of day to be outside, the physiological effect is that of much more moderate extremes. This is still more the case when the extreme dryness of the climate is considered, moderating the physiological effect.

During the 20 years here recorded the maximum has been as follows.

MAXIMUM

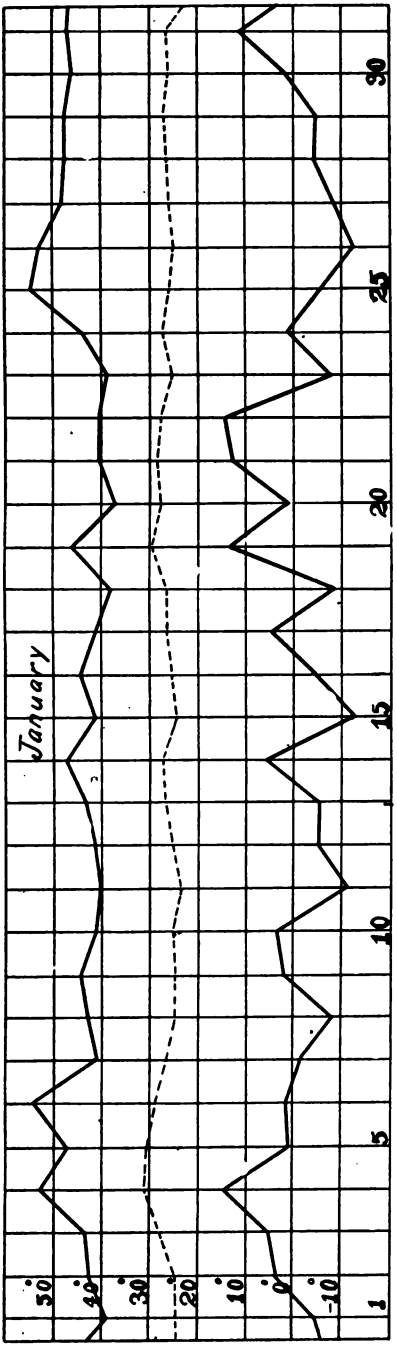
91°	1 year
93°	3 years
94°	3 years
95°	5 years
96°	2 years
97°	4 years
99°	2 years
99.6°	1 year

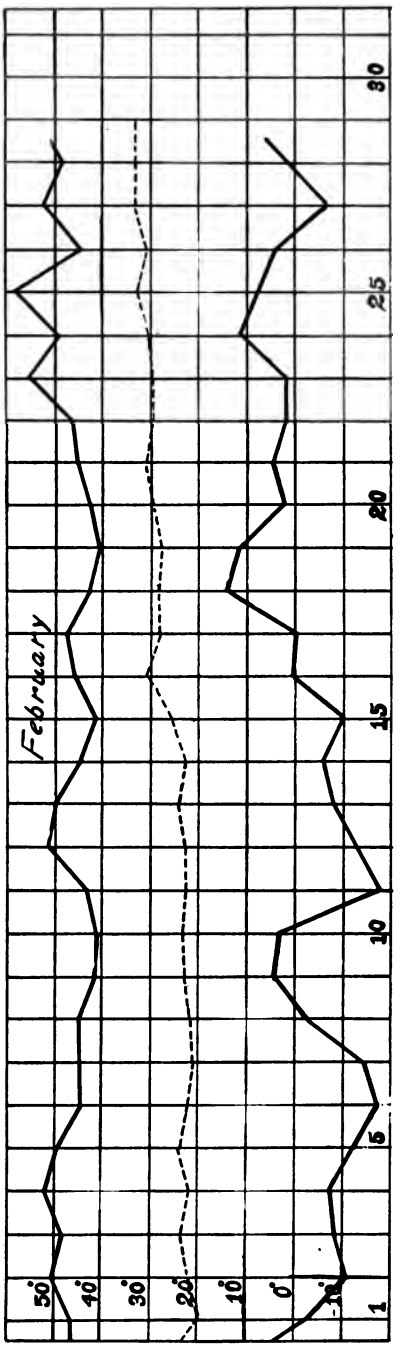
The minimum for the year has been as follows, below zero:

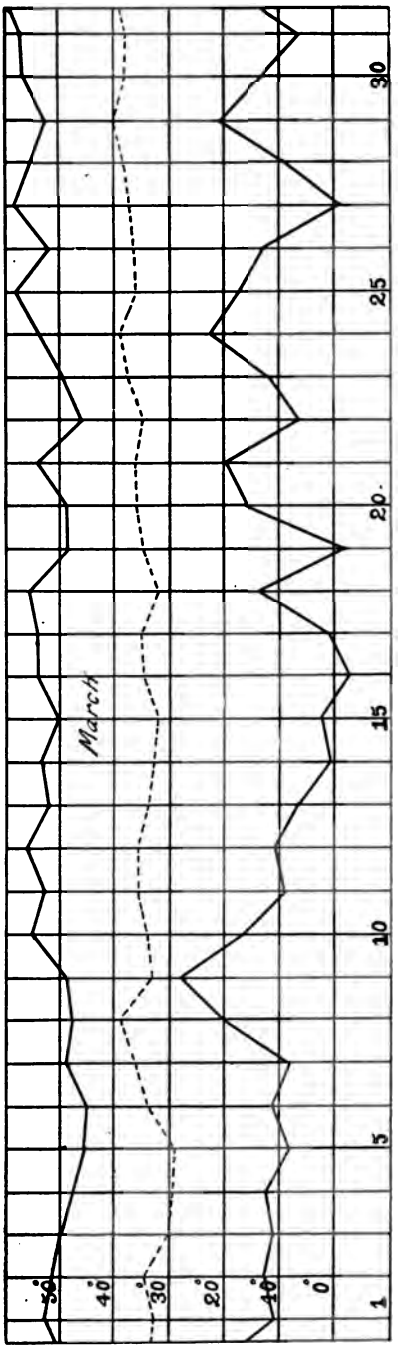
— 5°	1 year
6°—10°	2 years
11°—10°	2 years
16°—20°	4 years
21°—25°	4 years
26°—30°	6 years
31°—35°	2 years
—38.4°	1 year

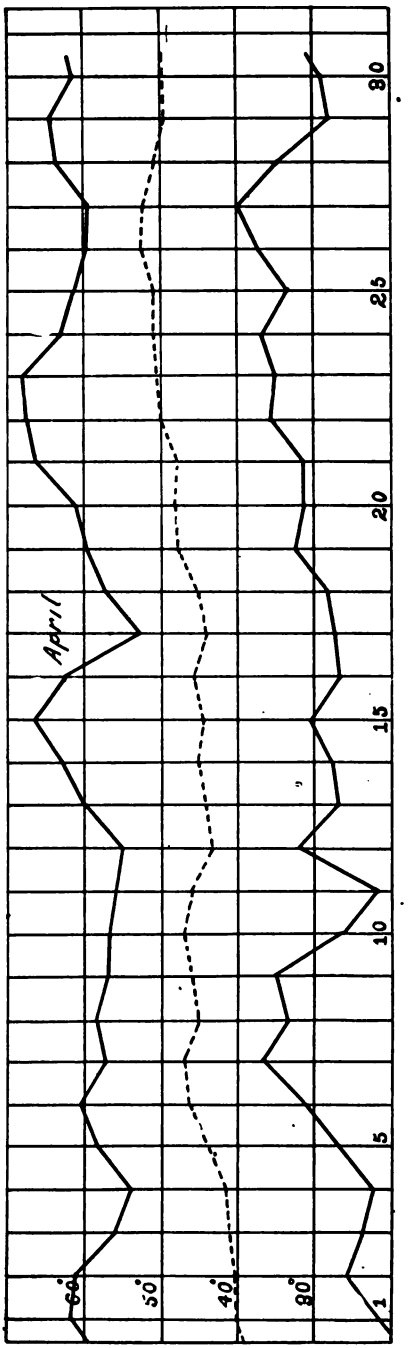
From the above record it is an even probability that the temperature will exceed or fall short of 94.6° for its maximum and -23° for its minimum. The average temperature is 45.7°, with a probable error of 0.2°; or it is an even probability from present information that after a much longer series of observations, the average will be found to be between 45.5° and 45.9.°

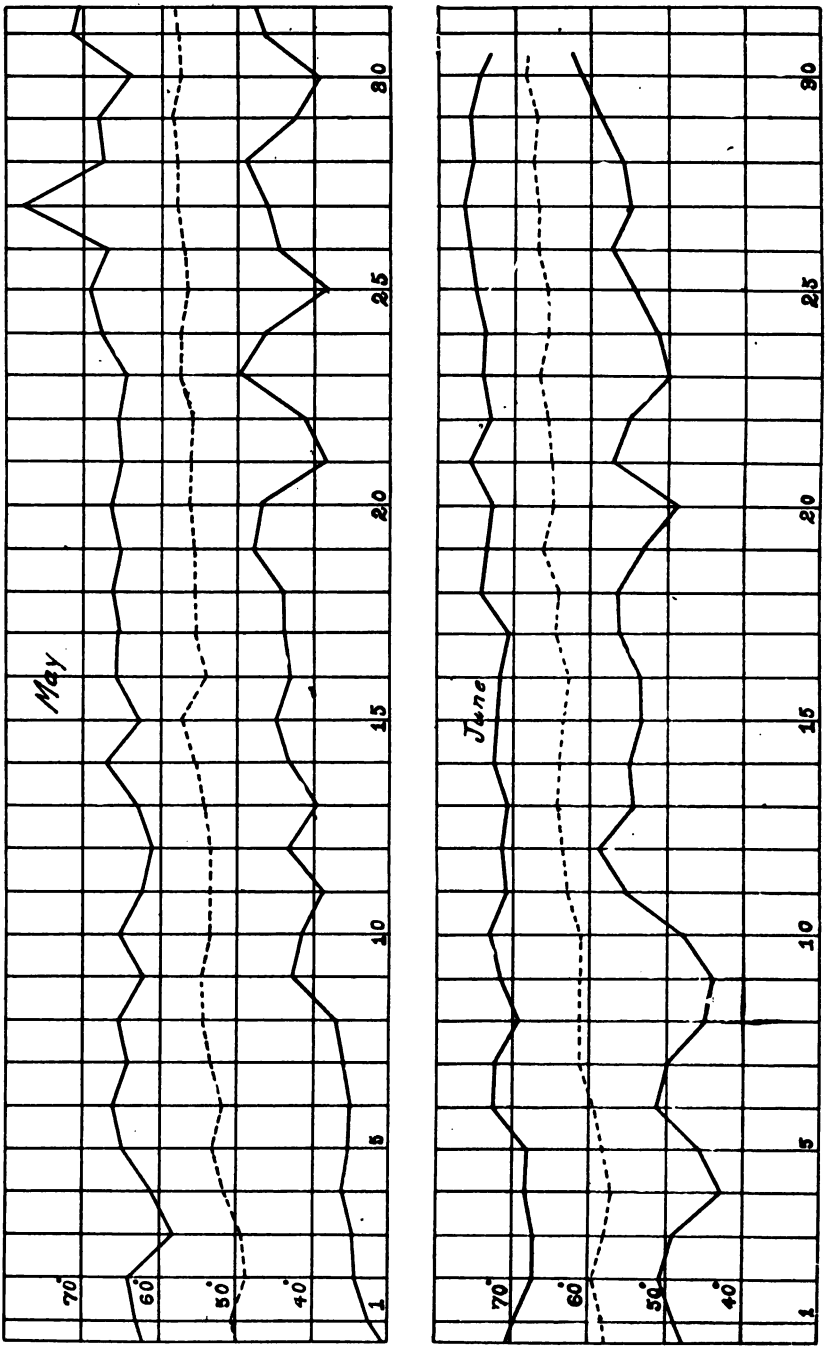
There is also given in Table I the monthly averages of temperature as found throughout the twenty years; in Table II, the table of extremes for each month; in Table III, the average daily range for each month.

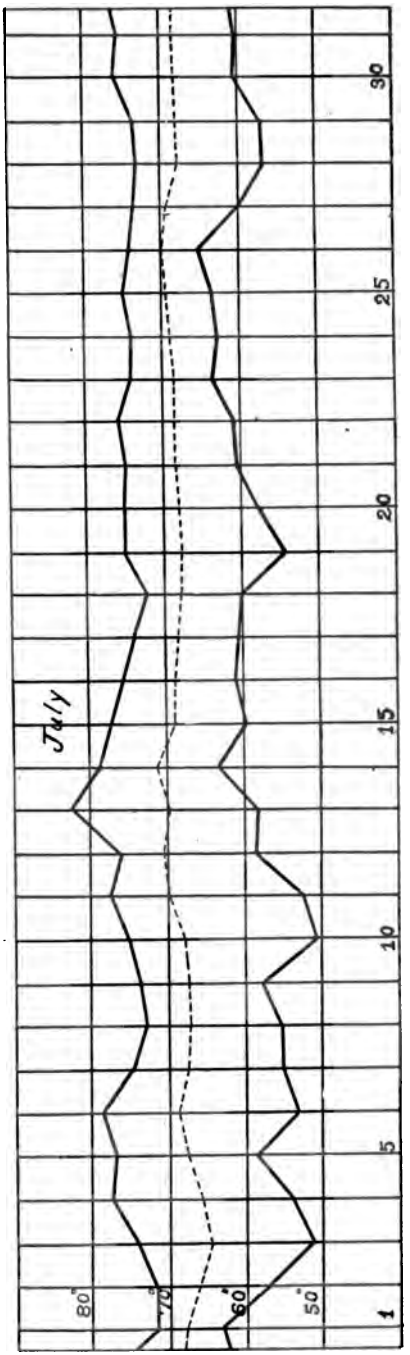

January
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30

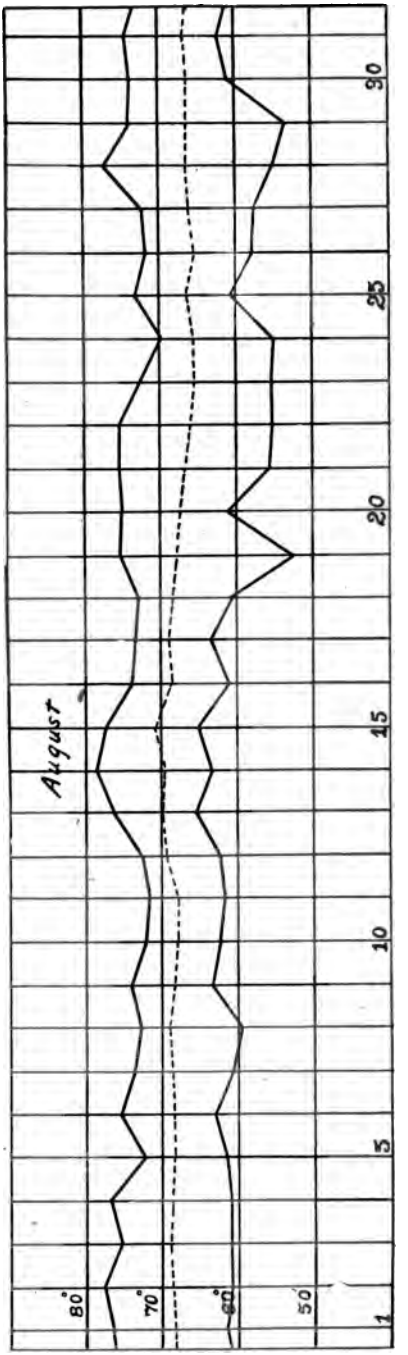

February
50°
40°
30°
20°
10°
0°
-10°
1
5
10
15
20
25
30

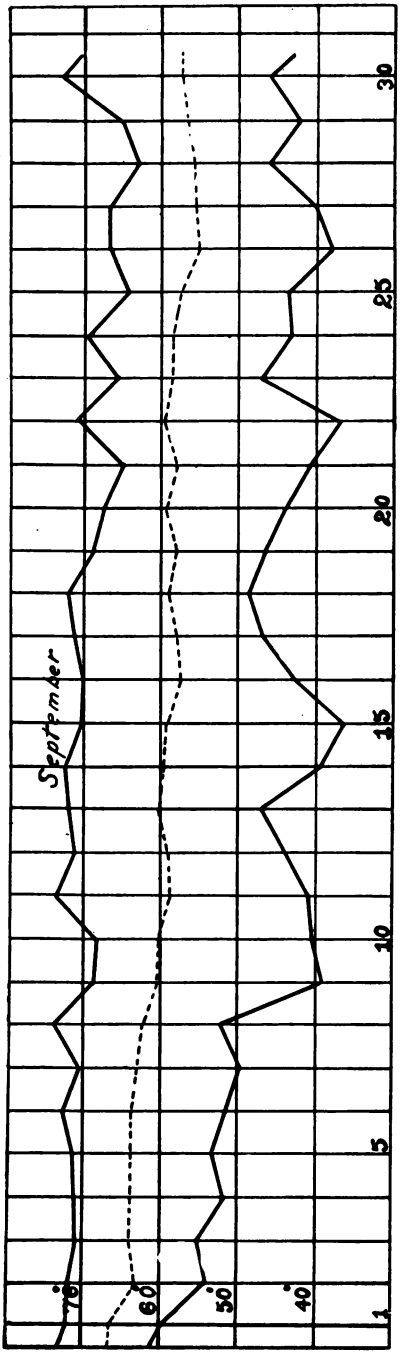

March
50°
40°
30°
20°
10°
0°
1
5
10
15
20
25
30

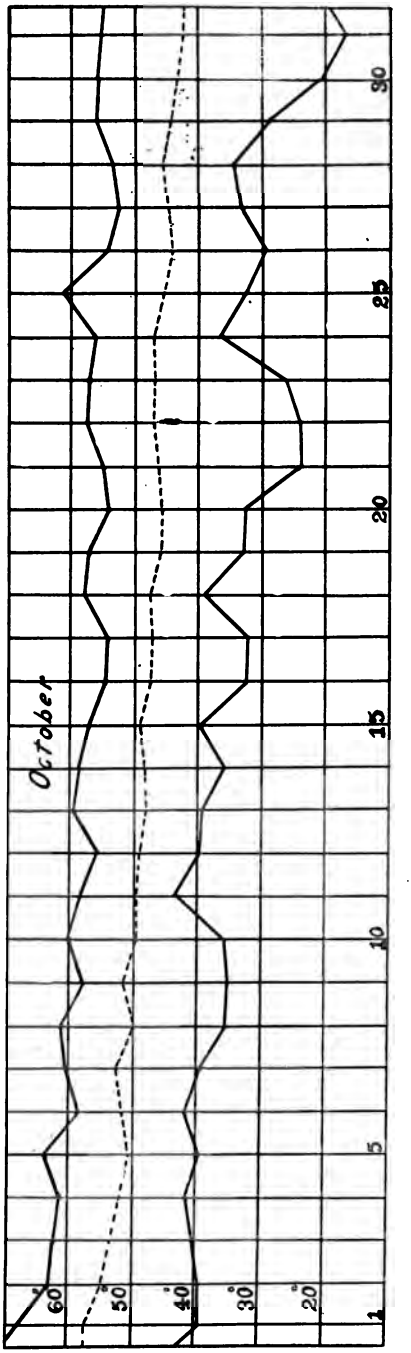

April
60°
50°
40°
30°
1
5
10
15
20
25
30

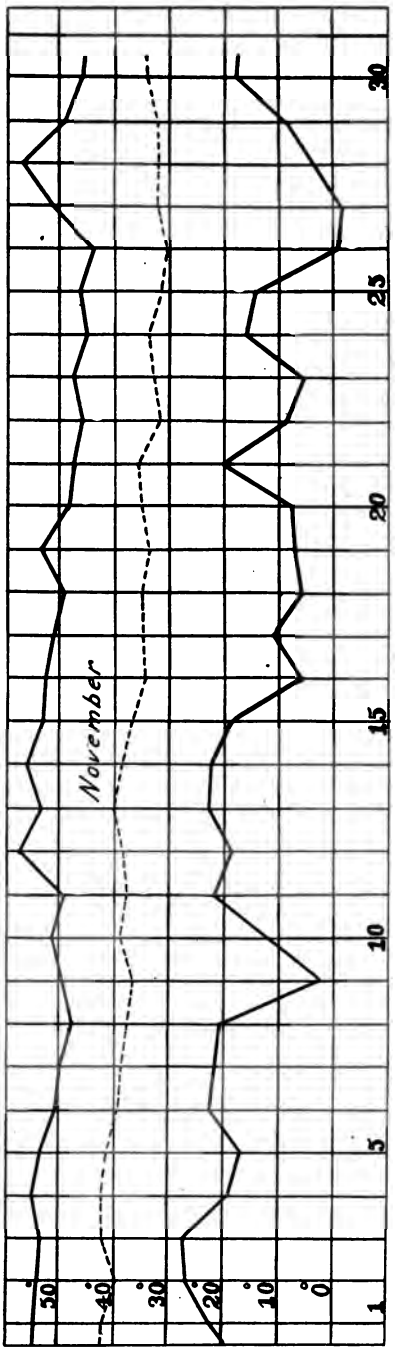

May
70°
60°
50°
40°
1
5
10
15
20
25
30
June
70°
60°
50°
40°
1
5
10
15
20
25
30


July
80°
70°
60°
50°
1
5
10
15
20
25
30


August
80°
70°
60°
50°
1
5
10
15
20
25
30


September
70°
60°
50°
40°
1
5
10
15
20
25
30


October
60°
50°
40°
30°
20°
1
5
10
15
20
25
30


November
50
40
30
20
10
0
1
5
10
15
20
25
30

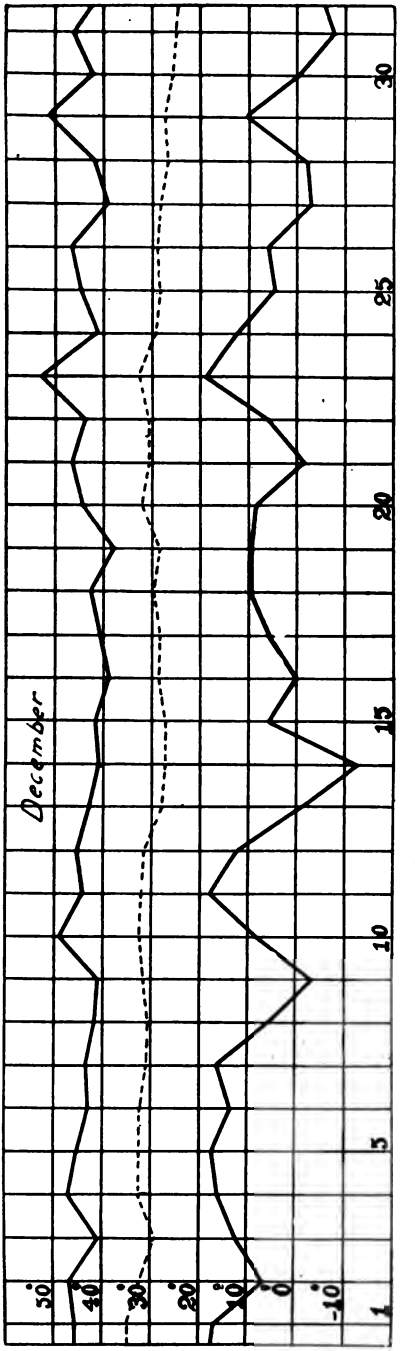

December
50
40
30
20
10
0
-10
1
5
10
15
20
25
30

TABLE I.

AVERAGE MONTHLY TEMPERATURE

At Agricultural College, Fort Collins, Colo., in Degrees Fahrenheit

YEAR	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1887.....	25.7	23.7	39.8	45.2	57.7	68.1	68.4	65.6	60.4	46.0	38.2	29.7	47.1
1888.....	22.2	37.1	37.4	55.3	54.4	68.1	72.8	66.6	61.4	49.2	33.0	31.3	49.0
1889.....	22.2	25.6	41.6	50.6	54.1	63.5	68.1	66.6	53.9	44.1	27.0	32.1	45.8
1890.....	24.7	30.0	38.0	46.5	58.0	64.0	71.1	66.1	58.3	47.4	38.1	37.8	49.1
1891.....	22.2	19.8	30.5	46.6	54.8	60.9	66.9	66.3	61.1	48.7	35.1	28.7	45.1
1892.....	21.1	27.8	33.7	44.0	50.0	61.7	68.2	67.3	62.4	47.7	37.4	23.1	45.4
1893.....	32.6	26.9	35.2	42.7	52.3	65.3	70.7	66.8	60.0	48.7	33.6	33.6	47.3
1894.....	23.9	18.7	37.4	48.3	57.2	63.2	69.1	68.3	58.9	51.3	40.5	25.6	46.9
1895.....	23.9	21.1	34.2	49.2	53.6	59.2	65.3	67.6	61.0	46.9	33.7	28.6	45.4
1896.....	32.6	33.4	34.0	46.6	57.0	65.3	70.2	69.0	58.8	48.0	30.8	34.0	48.3
1897.....	24.8	27.6	32.3	45.8	51.8	63.1	66.8	66.8	63.7	48.5	35.6	25.4	46.6
1898.....	25.6	34.1	32.7	47.7	51.6	64.0	69.0	69.9	58.6	46.3	30.3	23.6	46.1
1899.....	24.7	9.9	29.7	44.7	53.8	63.6	67.0	67.6	61.4	46.1	40.8	27.7	44.7
1900.....	30.9	24.2	39.1	42.9	57.8	67.1	67.9	68.0	58.6	50.2	37.4	31.6	48.0
1901.....	28.2	23.9	34.7	44.0	57.0	63.3	72.5	69.0	59.0	49.7	40.0	27.7	47.4
1902.....	24.2	32.0	35.3	45.7	56.1	63.6	66.0	68.7	56.8	48.8	36.1	27.1	46.7
1903.....	30.3	14.0	30.6	45.3	52.2	59.3	68.5	68.1	56.8	49.6	36.1	32.3	45.3
1904.....	26.1	35.3	39.6	46.2	53.7	59.9	65.6	67.0	59.2	48.9	39.7	31.9	47.8
1905.....	25.2	21.4	42.2	43.4	52.1	64.8	65.7	68.2	60.5	43.6	37.8	27.0	46.0
1906.....	30.9	30.5	25.0	47.1	55.0	61.8	64.9	67.2	58.7	46.3	33.6	34.8	46.3
1907.....	25.9	35.4	43.3	42.5	48.9	60.9	67.8	66.9	58.7	49.9	32.9	30.5	47.0
Average...	26.1	26.3	35.5	46.2	54.7	63.4	68.2	67.5	59.4	47.9	35.6	29.7	46.7

*Fort Collins, Colo., Agricultural College. Latitude, 40° 34'. Elevation, 4,993 Feet. Located on the Plains, 4 miles east of the foothills of the Rocky Mountains.

TABLE II.

EXTREME MONTHLY TEMPERATURES

At Agricultural College, Fort Collins, Colo.

YEAR	January		February		March		April		May		June	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1887.....	58.	**—19.0**	70.	— 8.	80.	8.	83.	16.	90.	24.	96.	45.
1888.....	71.	**—28.**	68.	14.	79.	3.	91.	30.	84.	30.	97.	42.
1889.....	58.	— 3.5	62.	—16.0	67.8	**—17.0**	79.	24.	81.	31.0	90.5	35.
1890.....	65.6	—13.0	68.3	**—20.0**	70.1	— 9.0	78.0	13.8	85.0	29.1	92.2	32.7
1891.....	48.9	**—16.3**	46.5	—1.50	66.0	— 4.1	81.9	12.9	84.6	31.2	86.9	37.9
1892.....	61.2	**— 28.4**	55.1	— 9.0	70.1	—19.7	78.7	19.4	82.0	31.4	86.5	35.4
1893.....	67.3	— 2.2	66.7	—10.0	78.3	— 1.9	78.9	7.6	88.7	23.1	**95.0**	31.3
1894.....	63.3	—22.0	54.6	—15.3	73.0	9.9	79.0	16.4	85.9	27.1	91.0	37.9
1895.....	57.2	— 9.6	62.2	**—27.8**	80.2	—18.0	78.7	17.0	90.0	28.6	88.7	33.0
1896.....	67.8	— 7.6	68.1	3.9	75.8	— 6.8	80.0	7.0	88.3	31.0	91.2	39.3
1897.....	64.0	**—26.0**	59.5	— 5.3	65.3	— 7.0	77.2	20.0	82.3	31.6	90.1	35.3
1898.....	61.5	—11.8	63.7	6.7	66.3	— 6.2	86.2	14.5	81.8	29.6	**97.2**	36.0
1899.....	55.0	—16.8	50.8	**—38.4**	65.7	—24.5	78.0	8.0	82.5	23.4	**96.1**	36.4
1900.....	63.0	— 6.0	56.0	**—23.4**	76.9	9.7	73.9	5.1	84.7	29.8	**94.4**	40.7
1901.....	61.8	— 21.7	63.0	—14.7	71.9	— 7.5	81.8	8.7	82.9	31.1	94.4	38.2
1902.....	62.2	**—31.4**	63.0	—23.0	63.9	2.0	79.8	18.0	85.9	29.6	96.0	37.0
1903.....	61.3	1.0	46.0	**—28.0**	66.2	—10.0	78.2	12.8	85.1	27.4	92.5	37.0
1904.....	65.0	**— 7.0**	69.0	3.0	70.0	10.0	79.8	14.1	82.0	28.2	87.2	38.4
1905.....	63.5	—22.3	66.2	**—26.8**	70.3	12.4	78.0	12.0	76.3	29.5	92.3	40.0
1906.....	67.8	— 3.5	67.0	— 5.0	69.9	**—24.6**	80.1	22.1	82.9	33.0	89.9	37.2
1907.....	62.6	— 4.7	68.8	— 2.8	80.3	2.8	80.0	5.7	83.0	19.2	87.7	33.9
Extreme	71.	—31.4	70.0	—38.4	80.3	—24.6	91.	5.1	90.0	19.2	97.2	31.3

TABLE II. (CONT'D.)

EXTREME MONTHLY TEMPERATURES

At Agricultural College, Fort Collins, Colo.

YEAR	July		August		September		October		November		December	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1887.....	97.	50.	97.	44.	91.	32.	88.	11.	78.	—13.	61.	0.
1888.....	99.	51.	88.	44.	89.	32.	75.	20.	64.	16.	68.	4.
1889.....	97.	37.5	97.	41.3	93.	23.0	85.2	24.9	61.	1.0	66.5	3.0
1890.....	93.4	46.9	95.3	39.5	85.3	28.0	77.0	15.7	75.7	6.5	62.9	5.8
1891.....	89.4	41.2	93.1	36.7	88.8	34.3	79.8	19.5	75.9	— 6.2	60.0	—10.0
1892.....	92.7	45.3	99.2	33.9	89.3	27.5	87.0	18.7	62.7	10.6	65.6	—17.4
1893.....	94.9	44.2	91.7	38.3	90.0	25.7	82.0	11.8	70.7	—12.8	60.4	2.5
1894.....	94.4	46.0	92.2	39.5	88.6	30.9	80.7	19.3	78.0	— 1.1	64.7	—24.0
1895.....	93.2	44.9	93.7	42.3	95.0	23.2	79.7	14.8	73.7	— 2.9	66.7	— 5.0
1896.....	95.8	48.8	93.8	40.2	90.0	31.8	84.2	21.0	74.7	—11.3	66.1	0.5
1897.....	94.8	38.9	93.5	42.7	89.8	33.8	81.7	21.5	75.6	— 3.0	63.0	—10.8
1898.....	97.0	44.3	95.6	43.1	90.2	29.7	85.7	16.2	71.3	—11.3	55.0	—22.3
1899	94.0	44.6	95.2	39.7	94.6	29.0	86.7	23.7	69.5	15.0	63.7	— 9.3
1900.....	92.9	40.2	94.0	41.2	88.2	29.7	83.0	12.5	74.0	8.7	62.9	—22.0
1901.....	96.7	47.9	96.7	43.6	86.6	29.4	82.0	25.0	69.6	12.0	64.6	—31.0
1902.....	98.0	38.8	99.6	42.3	89.8	22.0	80.0	25.5	69.2	3.8	58.2	—17.6
1903.....	95.0	36.0	94.6	41.9	92.5	26.0	81.0	20.0	71.0	—10.0	61.0	5.0
1904.....	90.7	40.3	91.0	33.0	90.0	29.6	80.1	17.8	75.4	0.5	65.7	1.0
1905.....	91.0	42.3	93.2	44.8	90.5	30.8	85.3	— 8.0	74.0	3.4	62.2	— 4.0
1906.....	92.6	41.0	92.0	39.2	86.9	37.3	83.2	19.4	70.2	— 9.3	64.5	7.0
1907.....	94.4	44.6	91.6	45.0	85.6	31.0	81.8	22.4	70.0	— 1.2	61.7	— 5.4
Extreme	99.	36.0	99.6	33.0	95.0	22.0	88.	— 8.0	78.0	—13.0	68.0	—31.0

NOTE.—Extreme temperatures of each year indicated by blackfaced type.

TABLE III.

AVERAGE DAILY RANGE OF TEMPERATURE

At Agricultural College, Fort Collins, Colo.

YEAR	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1887.....	23.2	31.5	35.3	28.6	32.6	33.1	29.7	31.7	32.8	33.6	30.8	27.6	30.9
1888.....	32.7	28.	31.3	32.7	24.5	28.6	32.6	29.8	35.9	28.0	23.9	31.1	29.9
1889.....	28.2	27.2	28.8	27.5	25.2	29.6	33.1	34.2	34.9	28.7	25.4	28.6	29.3
1890	30.2	30.0	29.7	26.9	30.2	34.4	31.9	29.7	37.4	32.7	33.6	31.3	31.5
1891.....	26.4	24.1	21.5	29.5	27.5	26.9	30.1	32.7	33.8	36.8	26.8	25.2	28.4
1892.....	28.0	22.8	23.7	29.2	22.2	30.4	30.6	37.7	40.6	32.3	29.0	27.5	29.5
1893.....	33.6	29.2	30.1	28.7	29.0	36.1	34.6	32.6	37.4	34.0	32.2	27.2	32.1
1894.....	31.0	30.0	29.9	32.5	28.8	32.2	32.6	33.4	34.8	34.3	34.5	29.5	32.0
1895.....	26.1	28.2	28.7	34.1	29.4	28.7	27.8	32.5	38.2	34.1	29.4	29.3	30.6
1896	32.9	31.5	24.5	32.3	31.5	31.4	29.2	32.2	28.0	33.2	28.5	30.1	30.2
1897.....	30.9	26.7	25.0	27.5	30.2	28.9	32.9	30.9	32.6	32.6	30.8	27.2	30.1
1898.....	30.1	33.0	30.4	33.6	22.3	31.7	32.1	35.4	39.4	29.6	28.4	28.6	31.2
1899.....	28.6	30.7	23.6	31.6	31.6	32.5	28.6	33.1	37.9	28.3	31.8	29.9	30.7
1900.....	31.4	27.1	29.6	23.3	29.2	33.8	31.6	37.0	30.6	34.8	31.4	31.3	30.9
1901.....	31.2	29.0	26.9	25.8	28.2	30.0	35.2	32.1	32.7	33.7	33.4	25.2	30.3
1902.....	30.0	27.0	25.5	30.6	28.8	30.8	33.0	32.8	34.6	31.3	27.0	25.5	29.7
1903.....	27.8	28.3	24.4	28.2	31.4	24.6	32.7	33.7	34.9	35.3	34.2	33.4	30.7
1904.....	33.3	30.2	30.4	29.7	25.0	27.1	29.7	31.6	33.7	35.0	39.9	32.0	31.5
1905.....	25.4	29.2	25.9	24.0	23.2	29.5	29.3	34.1	37.4	33.5	31.8	36.2	30.0
1906.....	33.0	35.5	23.0	25.7	28.1	39.1	27.9	32.2	28.8	31.6	24.9	26.6	29.7
1907.....	26.9	31.0	32.0	26.9	23.8	31.6	30.8	31.9	33.0	35.4	33.4	29.7	30.5
Average....	29.6	29.1	27.6	29.0	27.7	31.0	31.2	32.9	34.7	32.8	30.5	29.2	30.4

Bulletin 128 April 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

ALFALFA STUDIES

PROGRESS REPORT

BY

P. K. BLINN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915
GOVERNOR HENRY A. BUCHTEL, } *Ex-Officio.*		
PRESIDENT BARTON O. AYLESWORTH, }		

A. M. HAWLEY, SECRETARY — CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*,	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.,	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
W. H. OLIN, M. S.,	AGRONOMIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOUGLASS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S.,	ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS

STATE FRUIT INVESTIGATIONS

O. B. WHIPPLE, B. S., GRAND JUNCTION,	FIELD HORTICULTURIST
GEORGE P. WELDON, B. S., DELTA	FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

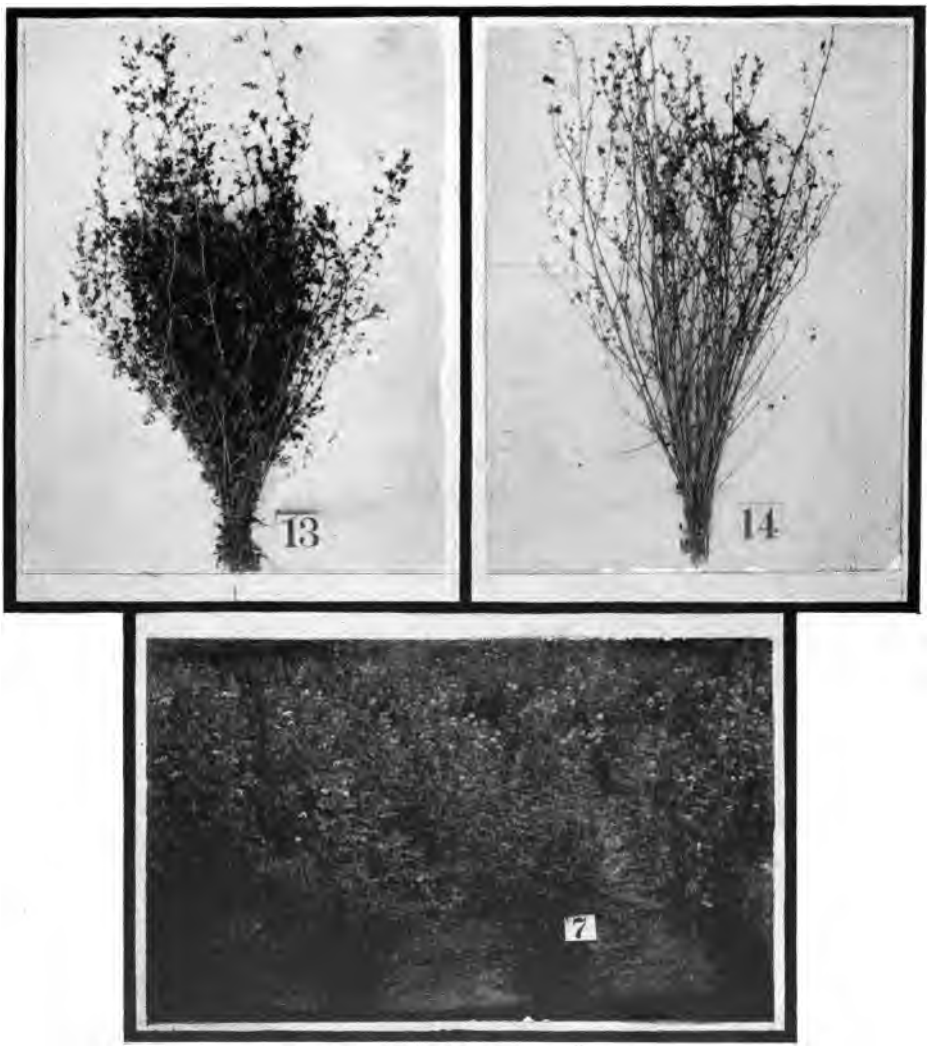


PLATE I.

No. 13. A-4, 7-12, yield of seed 5 grams. Desirable hay type.

No. 14. Plant A-5, 7-18, no seed. Leaves dropped by fungus.

No. 7. G-6. Arabian Plat just 4 months old from seed. In bloom.

ALFALFA STUDIES

PROGRESS REPORT

By P. K. BLINN

Alfalfa forms the basis of our farm values throughout the western states; its unique adaptation to the semi-arid conditions makes it an invaluable asset to our agriculture. Owing to its power to survive a drought, or exist on scanty moisture, its deep growing root system enables it to reach a great but a deep-lying supply of soil fertility, that is beyond the reach of common plant roots, but which will in turn, become available to any crop if the proper crop rotation with alfalfa is established.

The power of alfalfa to restore worn out lands, and to build up soil that is deficient in humus and nitrogen, is apparent to the most casual observer, who will compare the crops grown on alfalfa sod, with those on ordinary soil, or even where barnyard manure has been heavily applied. Realizing these facts, it is evident that alfalfa must be grown more extensively in our crop rotations to maintain and restore the soil that is being depleted by the large crops of sugar beets and other products.

Many acres of alfalfa hay land are sacrificed each year, for the more remunerative returns from beets, cantaloupes or potatoes grown on alfalfa sod, and as a result alfalfa hay is becoming scarce, and the price is advancing to a point that will tend to dishearten the stock feeder. Also the high prices realized for hay has not encouraged saving the alfalfa crop for seed, consequently the price of good alfalfa seed is about equal to the cost when it was first introduced. In the estimation of some, the high price of land in the irrigated sections precludes the use of alfalfa as a profitable crop; especially on the small tracts and even on the larger farms, the proper proportion of alfalfa to other crops is seldom maintained and evidently the *real merit* of alfalfa is overlooked.

When expensive land is occupied with alfalfa for recuperation, which sooner or later will become necessary, it is apparent to all that it should be made to yield the highest returns possible, in hay, seed or fertility. To this end the alfalfa seed breeding work has been instituted. The idea was suggested in 1904, when investigating the insect injuries and other causes for the poor yields of alfalfa seed in the lower Arkansas valley in Colorado. It was then noted that there was a great contrast in the seed yields of different plants under apparently the same conditions, and also, that the type and quantity of hay from different individuals varied. Seed from some of the most promising plants were secured and sown the following

season in a comparative test, with common alfalfa and some Turkestan seed from Germany, furnished through Professor W. H. Olin. This test the first season revealed a better seed production in the plants grown from seed selected for heavy yielding traits, but the second season's growth revealed the superior hay producing qualities of the Turkestan plants, which also yielded as high as an ounce of seed from a single plant. The selections that season were principally from the Turkestan plants, descriptions of which were reported in Bulletin 121, Colorado Experiment Station. Through Mr. J. M. Westgate, of the Department of Agriculture, a large list of foreign and native strains of alfalfa seed from different states were secured for a wider base of comparison in the preliminary nursery work of selecting the best strain for the improvement of the qualities desired in alfalfa.

The new alfalfa nursery planted the past season comprises sixty-four different varieties or promising individual selections, each planted at the same time and given the same care and conditions, and could be considered under a fair comparative test. Each plat was designed to contain two hundred individual plants, twenty inches apart each way, and each plat separated by a path forty inches wide.

The plats are designated in the following manner, the first tier of plats on the north are lettered "A" and numbered from east to west, one to eight, the next tier to the south is lettered "B" and the plats in the tier are numbered the same as the first tier, and so on, the eight tiers are lettered to correspond to the first eight letters of the alphabet.

The individual plants in a plat are designated by two numbers, the first denotes the number of the row in the plat, which is numbered from north to south, the second number denotes the plant in the rows, which are also numbered, but from the east to the west.

The nursery was planted April 15, 1907, and thinned to single plants about the middle of July. The following is an epitome of the first season's observations:

Plat A-1—Individual selection No. 1, from Turkestan variety, 183 plants. Irregular in type, undesirable for hay or seed compared to others.

Plat A-2—Individual selection No. 2, from Turkestan variety, 163 plants. Irregular in type, rather subject to fungus diseases.

Plat A-3—Individual selection No. 6, from Turkestan variety, 146 plants. Irregular in type, but fair for hay, no seed formed.

Plat A-4*—Individual selection No. 17 (from single plant on railroad right-of-way, grown without irrigation). Very uniform in type, upright in growth, fine stems and leaves, good hay type and fair set of seed, 165 plants. Very continuous in bloom.

Plat A-5*—Individual selection No. 12, from Turkestan plants, 179 plants. Irregular type, coarse stems, very sprangly growth, leaves shed off badly, no seed.

*See Plates.

PLATE II.

No. 16. Argentine alfalfa. From Plat E-4, 6-14. Good hay and seed type. 12 grams of seed.

Contrast in size of bloom.

No. 17. Argentine alfalfa. From Plat E-2, 1-19. Good hay and seed type; 13 grams.

Plat A-4, after plants were cut.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

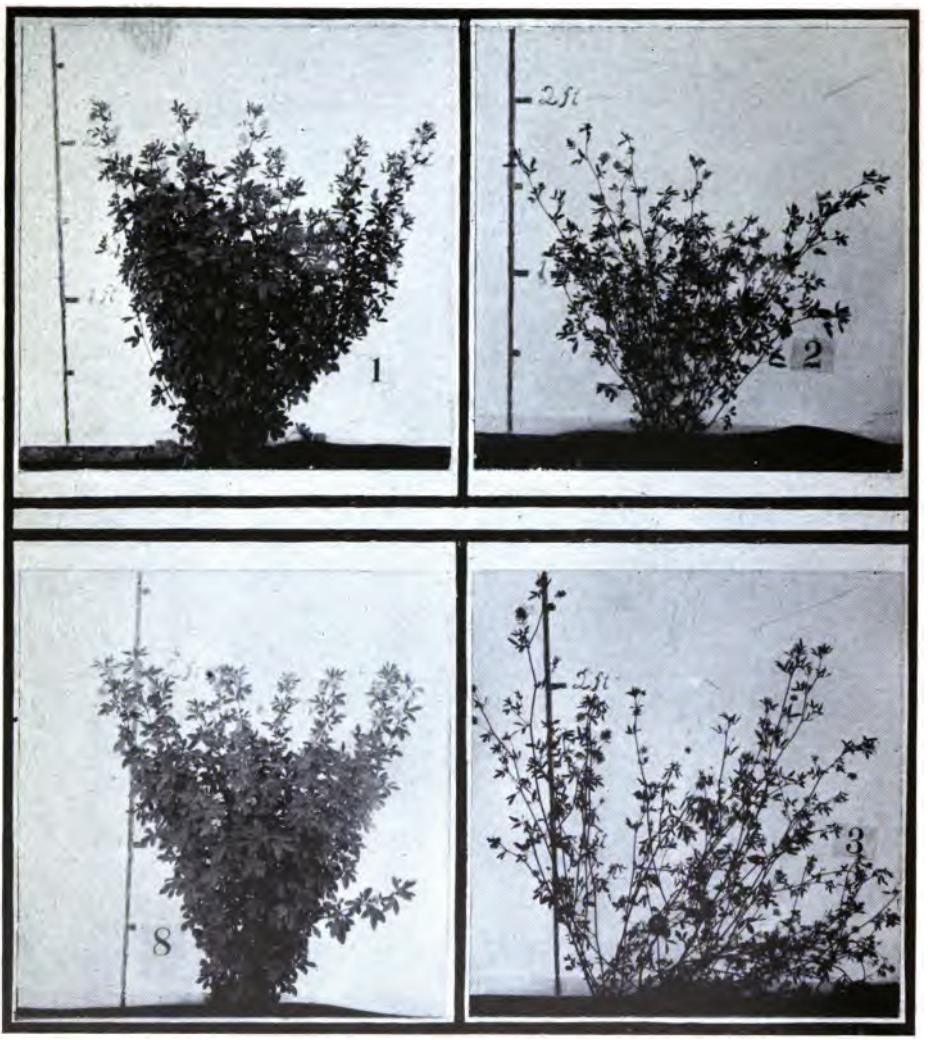


PLATE III.

No. 1. Arabian alfalfa, Plat D-2, 9-12. No. 2. D-2, 2-9.

Contrast in individual plants same age.

No. 8. Plat E-6, 9-5. Arabian alfalfa. No. 3. Plat D-3, 2-5. Mexican alfalfa.

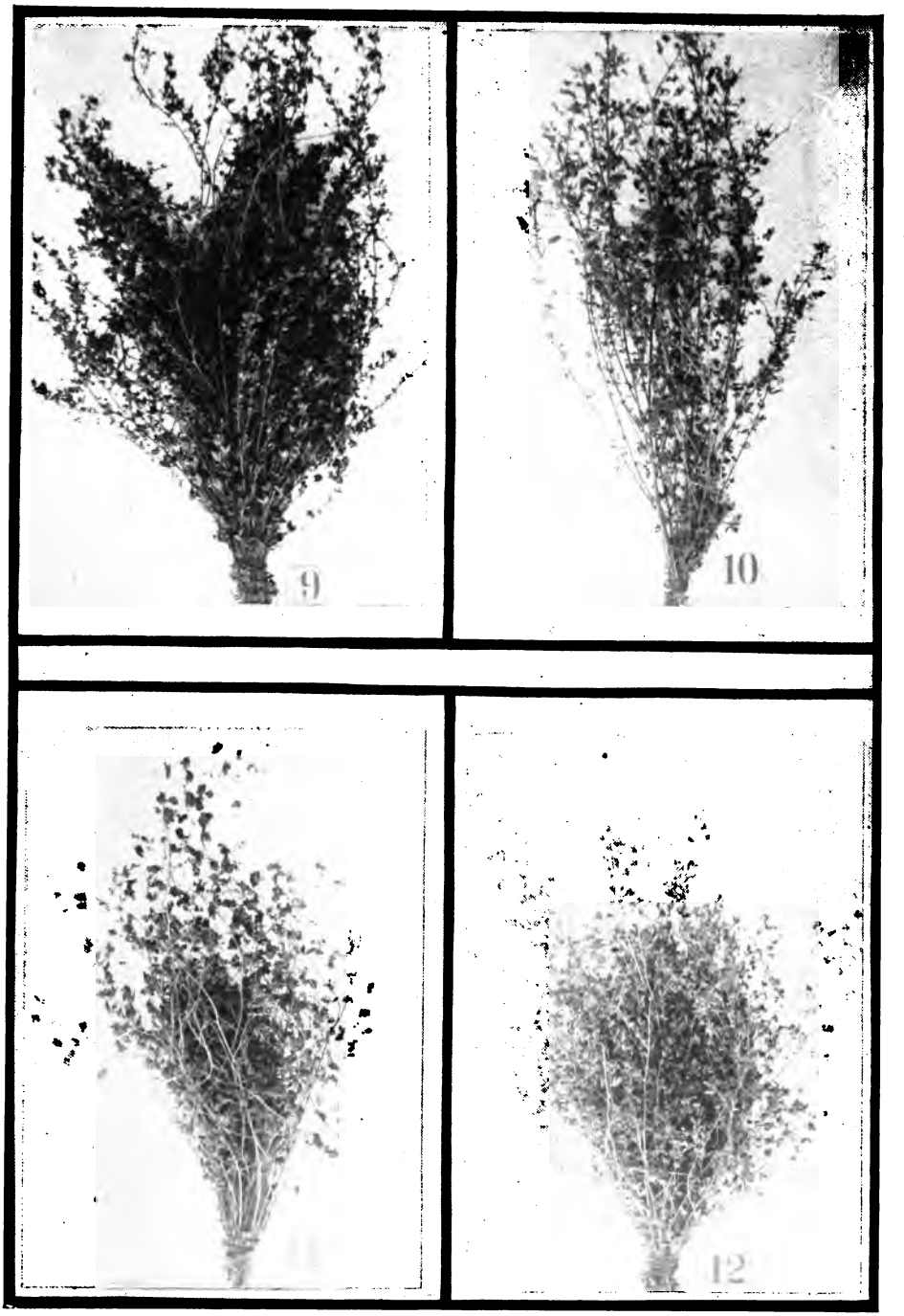


PLATE IV.

No. 9. Argentine. Plat E-4. Plant 7-6. Thickly set to leaves. Yield of seed, 2 grams.

No. 10. Ecuador. Plat E-8. Plant 7-1. Tall, stiff stems, set well to seed. Yield, 7 grams.

No. 11. Utah. Plat D-8. Plant 6-1. Remarkable yield of seed. 24 grams from 1 plant.

No. 12. Ecuador. Plat E-8. Plant 3-4. Fine combination of seed and hay quality. 15 grams.

LIBRARY OF THE UNIVERSITY

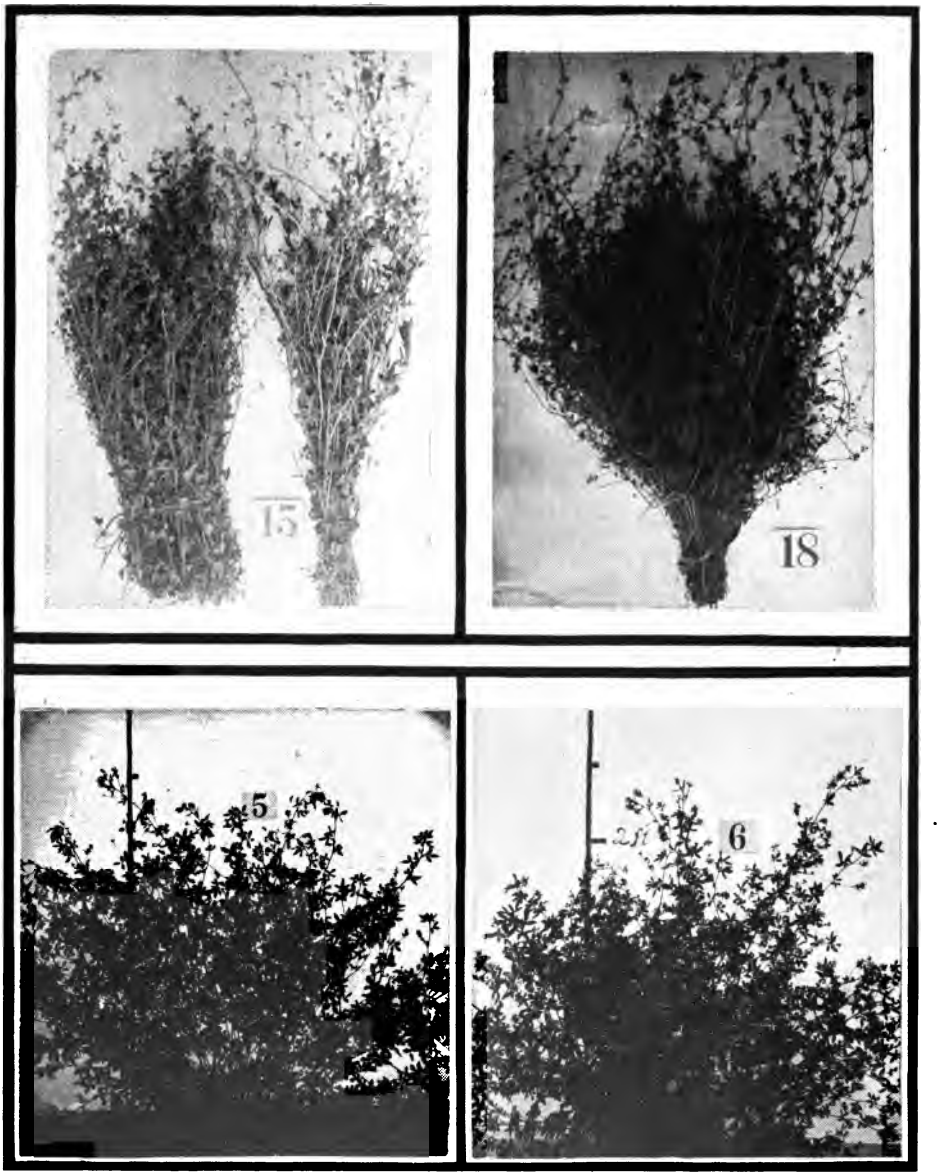


PLATE V.

No. 15, from Plat E-3. Dry land Nebraska. Plant 10-17, to left. Remarkable stooling trait, 250 stems from one single plant the first year. Yield of seed, 7 grams.

No. 18, from Plat D-5, 6-20 Sand Lucerne, Pullman, Wash. Extra fine stems and leaves, fine hay type. Yield of seed, 4 grams.

Contrasting Qualities of Single Plants.

No. 5. From Plat E-4, 10-1. Argentine. This plant grew adjacent to No. 6, and shows that while they are similar in size there is a contrast in seed yield. Yield, 6 grams.

No. 6. From Plat E-4, 9-4. Argentine. This plant, while a fine hay type, is also a good seed yielder; produced 20 grams.

Plat A-6—Individual selection No. 16, from Turkestan variety, 153 plants. Irregular type, sprangly stems, but fair for hay, no seed.

Plat A-7—Individual selection No. 10, from Turkestan variety, 147 plants. Fairly regular in type, but leaves much affected with fungus, no seed, hay qualities fair.

Plat A-8—U. S. Department No. 991, Turkestan, 35 plants. Very poor.

Plat B-1—U. S. Department No. 12231, Texas Turkestan, 74 plants. Very irregular in type, but some good plants, no seed.

Plat B-2—Individual selection No. 3, Turkestan variety, 172 plants. Fairly uniform and hay qualities fair, no seed.

Plat B-3—Individual selection No. 7, Turkestan variety, 183 plants. Quite uniform, tall, coarse stems, no seed, good yield of hay.

Plat B-4—Individual selection No. 15, Turkestan variety, 180 plants. Fairly uniform in type, very dense set of leaves, very promising hay type, but no seed.

Plat B-5—Individual selection No. 9, Turkestan variety, 185 plants. Tall, coarse stems, no seed, hay fair.

Plat B-6—Individual selection No. 13, Turkestan variety, 181 plants. Fairly uniform type, hay good, no seed.

Plat B-7—Individual selection No. 11, Turkestan variety, 151 plants. Poor hay type, few leaved.

Plat B-8—U. S. Department No. 13999, Turkestan from Washington, 72 plants. Poor stand, but good hay type, but no seed.

Plat C-1—U. S. Department No. 12231, Turkestan from Texas, 29 plants. Poor plat.

Plat C-2—Individual selection No. 5, Turkestan, 166 plants. Fair type for hay, but no seed.

Plat C-3—Individual selection No. 8, Turkestan variety, 178 plants. Tall, stiff stems, coarse hay.

Plat C-4—Individual selection No. 14, Turkestan, 166 plants. Short stems, hay fair, no seed.

Plat C-5—U. S. No. 13521, Algeria, 66 plants. Hay fair, leaves free of fungus, no seed.

Plat C-6—U. S. No. 12803, Setif, Algeria, 123 plants. Hay fair, no seed, leaves free of fungus.

Plat C-7—U. S. No. 12846, Kebelli, Tripoli, 97 plants. Poor plat.

Plat C-8—U. S. No. 16401, Dryland, Pullman, Wash., 83 plants. Irregular in type, some good plants for hay and seed.

Plat D-1—U. S. No. 8823, Arabian, 61 plants. Regular type of upright stems, no seed, poor hay qualities.

Plat D-2*—U. S. No. 12992, Arabian, 129 plants. Very irregular, no good.

Plat D-3*—U. S. No. 11651, Pueblo, Mexico, 76 plants. Irregular type, but some good hay types, no seed.

Plat D-4—U. S. No. 14786, Turkestan, 143 plants. Tall, coarse stems, fair for hay, no seed.

Plat D-5*—U. S. No. 16399, Sand Lucerne, Pullman, Wash., 140 plants. Hay type good, seed fair.

Plat D-6—U. S. No. 17698, Northern Montana, 156 plants. Extra good hay type, thick set to leaves, free of fungus, no seed.

Plat D-7—U. S. No. 12847, Tebis, Tripoli, 60 plants. Much like Arabian alfalfa, upright stems, no seed.

Plat D-8*—U. S. No. 18827, Utah, 121 plants. Extra good type for both hay and seed in some plants, rather irregular on whole.

Plat E-1—U. S. No. 11652, Mexico, 98 plants. Irregular type, but some good plants for seed.

*See Plates.

Plat E-2*—U. S. No. 13768, Argentine, 143 plants. Extra good hay and seed type, leaves free from fungus.

Plat E-3*—U. S. No. 19566, Dryland, Nebraska ,169 plants. Good hay type, seed fair.

Plat E-4*—U. S. No. 12549, Argentine, 142 plants. Irregular types, but some extra good for hay and seed.

Plat E-5—U. S. No. 18470, Sand, Lucerne, Germany, 97 plants. Fair type for hay, no seed.

Plat E-6*—U. S. No. 16267, Irrigation Arabian, 106 plants. Regular in type, upright stems, large leaves, but sun scalded, no seed.

Plat E-7—U. S. No. 16317, China, 115 plants. Very sprangly, hay and seed poor.

Plat E-8*—U. S. No. 14972, Ecuador, 170 plants. Wonderful set of seed, hay fair.

Plat F-1—U. S. No. 11502, Siberia, 48 plants. Very poor traits.

Plat F-2—U. S. No. 13564, Peru, 138 plants. Short stems, fine, thick set with leaves, good seed and hay yield, seed not filled well.

Plat F-3—U. S. No. 9453, Turkestan Bokhara, 30 plants. Very poor types.

Plat F-4—U. S. No. 12772, Turkestan, Oregon, 111 plants. Irregular, hay and seed fair on some plants.

Plat F-5—U. S. No. 16403, Turkestan, Washington, 131 plants. Irregular, some good plants for hay and seed, stiff stems.

Plat F-6—U. S. No. 1159, Turkestan, Kuldja, China, 30 plants. Plants flat on the ground, no good.

Plat F-7—U. S. No. 19969, Highmore, South Dakota, 138 plants. Extra good hay and seed types in some plants.

Plat F-8—U. S. No. 19968, Turkestan, Kansas, 96 plants. Tall, coarse stems, no seed.

Plat G-1—U. S. No. 14497, Russia, 146 plants, Turkestan type. Hay and seed type fair.

Plat G-2—U. S. No. 13437, Arizona, 144 plants. Hay and seed qualities good.

Plat G-3—U. S. No. 18751, Turkestan, 154 plants. Coarse, stiff stems, few leaves, no seed.

Plat G-4—U. S. No. 9395, Turkestan, 75 plants. Sprangly, stiff stems, few leaves, no seed.

Plat G-5—U. S. No. 19508, Kansas, 132 plants. Well set with leaves, good hay type, seed fair.

Plat G-6*—U. S. No. 18628, non-irrigated Arabian, 142 plants. Upright stems, sun scalded tops, no seed.

Plat G-7—U. S. No. 13519, Spain, 142 plants, Arabian type. Hay fair, no seed.

Plat G-8—U. S. No. 13436, Canada, Ontario, 114 plants. Sprangly type, hay and seed only fair.

Plat H-1—U. S. No. 13440, Kansas, 132 plants. Thick set to leaves, good hay, seed set fair.

Plat H-2—U. S. No. 13487, Texas, 146 plants. Good hay type, seed on some plants.

Plat H-3—U. S. No. 679, Turkestan, Bokhara, 54 plants. Very poor type.

Plat H-4—U. S. No. 9452, Turkestan, 96 plants. Very tall stems, few leaves, no seed.

Plat H-5—U. S. No. 18591, Turkestan, Montana, 136 plants. Sprankly stems, hay and seed no good.

Plat H-6—U. S. No. 18425, Turkestan, 123 plants. Sprangly type, seed and hay no good.

*See Plates.

Plat H-7—U. S. No. 9450, Turkestan, Trans-Caucasia, 6 plants. Failure.

Plat H-8—U. S. No. 17792, Spain, 139 plants. Upright form like Arabian, hay and seed only fair.

In all our previous tests the Turkestan alfalfa has proven the most desirable in type for hay. It will be noticed from the above report of nursery that one-half of the plats were sown with Turkestan strains, yet the most leafy plants, and those producing the most seed, were not found in the Turkestan varieties. The second season's growth may reveal different records. Of the plats that produced seed, and were of promising type for seed and hay, the following selections were made, besides the individual selections of exceptional qualities:

Plat A-4—Seed from 150 plants, fine, leafy stems, quite uniform seed producing, secured 11 ounces of clean seed.

Plat E-8—From 50 plants, of heavy seed producing quality, secured 18 ounces clean seed.

Plat C-8—From ten choice plants secured 87 grams of clean seed, plants of short, jointed stems, thickly leaved and fairly set to seed.

Plat D-7—Seed of ten plants of the Arabian type, 71 grams.

Plat D-8—Seed of ten plants of the thick, fine leafed type, 70 grams.

Plat F-2—Seed of ten plants of the short, dwarfed stems, 118 grams.

The above six selections were made with a view of sowing increase plats in order to get seed in considerable amount, as these selections seemed so much superior to the common alfalfa. Besides this the following single plant selections were made, for their individual merit.

Bulletin 129. May 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Extraction of Beeswax

BY

F. C. ALFORD

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		TERMS EXPIRE
HON. JAMES L. CHATFIELD	Gypsum	1909
HON. B. U. DYE	Rocky Ford	1909
HON. B. F. ROCKAFELLOW, *President*	Canon City	1911
HON. E. H. GRUBB	Carbondale	1911
HON. R. W. CORWIN	Pueblo	1913
HON. A. A. EDWARDS	Fort Collins	1913
HON. F. E. BROOKS	Colorado Springs	1915
HON. J. L. BRUSH	Greeley	1915
GOVERNOR HENRY A. BUCHTEL, PRESIDENT BARTON O. AYLESWORTH,	*ex-officio.*	

A. M. HAWLEY, SECRETARY — CHAS. SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director* ..... IRRIGATION ENGINEER
C. P. GILLETTE, M. S. ..... ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D. ..... CHEMIST
WENDELL PADDOCK, M. S. ..... HORTICULTURIST
W. L. CARLYLE, M. S. ..... AGRICULTURIST
G. H. GLOVER, M. S., D.V. M. ..... VETERINARIAN
W. H. OLIN, M. S., ... AGRONOMIST
R. E. TRIMBLE, B. S. ..... ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S. ..... ASSISTANT CHEMIST
EARL DOUGLASS, M. S. ..... ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S. ..... ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S. ..... ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S ..... ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S. ..... ASSISTANT AGRONOMIST
W. G. SACKETT, B. S. ..... BACTERIOLOGIST
P. K. BLINN, B. S. ..... FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S. ..... POTATO INVESTIGATIONS
MIRIAM A PALMER ..... ARTIST
L. C. BRAGG ..... ASSISTANT IN ENTOMOLOGY
STATE FRUIT INVESTIGATIONS:
O. B. WHIPPLE, B. S., Grand Junction ... FIELD HORTICULTURIST
GEO. P. WELDON, Delta ..... FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S. ..... DIRECTOR
A. M. HAWLEY ..... SECRETARY
MARGARET MURRAY ..... CLERK

EXTRACTION OF BEESWAX

BY F. C. ALFORD

The increasing interest in apiculture in many sections of the State, and the frequent inquiries relative to the best method of extracting the wax, justify the preparation of this bulletin.

The combs used for the extraction of wax are usually old brood combs. These, of course, contain a large amount of foreign matter which renders the complete extraction of the wax very difficult, and results in forming a residue, known as slumgum.

Some of the methods in vogue at present have been practiced for a long time, others are of comparatively recent origin. Though I have sought for data, definitely established by experiments, regarding the relative efficiency of the different methods, I have been unable to find such, and have therefore attempted to establish the efficiency of some of the methods by experiments.

The classes of extractors experimented with include the solar extractors, those using steam, and those employing pressure under water at a temperature sufficiently high to melt the wax. We have experimented with the latter, using water alone, and also with the addition of sulphuric acid.

All experiments in extracting the wax were made with portions of one large lot of comb, and under comparable conditions. In those cases in which specific instructions were sent out by the manufacturers of the extractor, they were followed faithfully.

The study of this subject was extended to include the refining and bleaching of the wax, and also to include an indicator to find out something definite relative to the character and wax content of slumgum.

In all of this work we have been mindful of the suggestions and theories advanced by apiculturists during recent years, which was, of course, necessary in order to bring our work abreast with that of the Bee-keepers' Associations and individuals. I have profited by the suggestions of some of the prominent refiners of and dealers in beeswax who kindly answered my inquiries addressed to them, but in general I have found information regarding the extraction of beeswax very scarce, at least it is very difficult to obtain.

The General Properties of Beeswax. Beeswax, when obtained from clean, fresh comb, is a tough, compact solid, having a yellowish or brownish color, a fine granular structure and a very little luster. Its taste is faint and balsamic, but the odor is honey-like and characteristic. Beeswax does not feel greasy to the touch. It loses is color, bleaches, when exposed to the action of moisture and light, some varieties with

great difficulty. The presence of a small amount of fatty matter seems to facilitate the process. The melting point of beeswax varies with different samples, due to the fact that the proportion of its constituents may vary. The melting point is higher in old than in fresh wax, i. e., the melting point increases a little as the wax ages. Yellow wax melts between 61° and 63° C. (141.8° and 145.8° F.) Its specific gravity varies from 0.96 to 0.97 at 4° C.

The average composition of beeswax is, cerotic acid, soluble in alcohol, 14.4%; myricin, insoluble in alcohol, 85.09%. There are, further, other compounds present, two hydrocarbons having been definitely recognized. The composition of genuine beeswax is approximately constant, and is not changed by natural bleaching, but chemical bleaching may increase the relative percentage of acid to 17 or 18%.

Comb Used. As the comb varied considerably, care was taken to get a fair sample for each experiment. The comb used was mostly old black comb which had been used as brood comb and was furnished by some of the beekeepers of the state and the Entomologist of the Station. The comb was sorted into three different grades; that designated as comb number one was white comb which had not been used for breeding purposes. Number two comb was light brown, which had been used as a brood comb. It was darker than number one but not as dark as number three. Comb number three was a real dark comb and had been used for breeding purposes for a long time. Almost all of the experiments were conducted with combs numbers two and three, as almost all methods are very efficient with comb like number one.

Samples. Realizing that a little difference in the samples taken for the experiments would make a greater difference in the final result, we were very careful in the sampling of the material for the experiments. The comb was cut into pieces about an inch square and placed in a pile. The pile was stirred until well mixed, divided into quarters and the two opposite quarters placed in a pile. This pile was stirred and sampled as before. This process was continued until a sample of the proper weight was obtained.

SOLAR EXTRACTORS.

Two kinds of solar extractors were used, known as numbers one and two. Number one consisted of a wooden box thirty-two inches long, eighteen inches wide, and four inches deep. At the lower end a small box is placed to hold the pan which catches the wax. Twenty-four inches from the top there is a screen to hold back the comb. The upper portion of the box is lined with tin and the waste wax and brood comb are placed in this part of the box. The box is covered with a pane of glass held in a frame which fits the upper edge of the box. The heat from the sun melts the wax and it runs down, is strained by the screen, and is collected in a pan at the lower portion of the tin.

Number two extractor consists of a wooden box sixteen inches broad, seven inches deep and thirty inches long and has legs near one end so that it can be raised up at an angle toward the sun. The interior

is fitted with a concave tin lining to hold the pieces of comb, separated by a wire cloth straining screen from the wax pan, at the lower end of the box.

These two extractors were used because it was thought they represented, as nearly as possible, the average of the solar extractors used in this country. Some beekeepers have solar extractors which are much larger than either of these, but it is doubtful if they remove a greater percentage of the wax from the comb.

The experiments conducted with the solar extractors were made, as nearly as possible, under the same conditions. They were made on the same day and within a few feet of each other, on the south side of the Chemical Laboratory, so as to get the same outside temperature.

Number one held about twice as much comb as number two. On this account, it was necessary to fill number two extractor twice while number one was filled once. The first experiments were made to determine the comparative efficiency of these two solar extractors. For number one comb, extractor number two produced on the average about one per cent. more wax; for number two comb, about two per cent. more, and for number three comb, about one per cent. more than extractor number one.

The temperature of the extractor varied so much on different days that it was very hard to tell which extractor had the higher temperature. One day number two would have a higher temperature and the next day number one would. Taking an average of all the experiments where the temperatures were taken I find extractor number two exceeded extractor number one by about 0.4°C.

Solar Extractor with Lamp. It is the practice of some beekeepers to operate a lamp, stove or furnace in connection with the solar extractor. The extractors were inclined at an angle of about thirty degrees and an inclosure built back of them, to keep the wind from blowing the lamp. A lamp was placed inside the inclosure and a hole made in the bottom of the extractor so that the flame would strike against the tin lining of the extractors.

The addition of the lamp helped the extractor to heat up in the morning, to remain warm in the evening, and on a cloudy day, to keep the extractor warm when the sun was under a cloud.

By the use of the lamp the efficiency of the extractor was increased on an average about one per cent. The best results were obtained by having the heat from the lamp strike directly under the wire screen. Often on a cloudy day the wax will run down as far as the screen and then cool. By having the heat from the lamp warm the screen and the surrounding metal the wax is kept from cooling and runs down into the pan.

Double Glass. It was thought that the addition of an extra pane of glass might increase the yield. In order to try this an extra pane of glass was placed on extractor number one with one-half inch space between the panes. It was found that the use of the second pane increased the inside temperature on an average about 9.4° C. (17° F.) It was

observed that the extractor with the double glass was slower in becoming heated in the morning and held the heat longer in the evening. The efficiency of the extractor was increased, on an average, about seven per cent. for number two comb, and two per cent. for number three comb. Number one comb was not tested.

Double Glass and Lamp. As it was shown by experiments that the use of a lamp, and an extra pane of glass increased the efficiency it was thought that a combination of the two might increase it still more. This was tried and the results showed but a slight increase over either one alone and did not come up to expectations. The increase was about 0.7 per cent.

Bleaching. It was noticed that in rendering light colored wax by means of the solar extractor the wax was bleached. An attempt was made to determine the bleaching effect of the sunlight by exposing dark wax in the solar extractor for four days. The wax was exposed for that length of time because it was thought that it would not remain in the extractor longer than that during the ordinary process of extraction. Some dark wax which had been obtained from the Ferris steam extractor was placed in solar extractor number one and melted for a day. A sample of this wax was taken and the remainder remelted. This was continued for four days and samples were taken at the end of each day. At the end of the fourth day the samples were compared and it was impossible to note any change in the color of the wax.

Some dark wax which had been boiled with sulphuric acid was placed in solar extractor number two and melted. It was sampled and remelted the same as in the preceding experiment. It was impossible to notice any difference in the shade or color of the wax.

Slumgum. In order to see if the solar extractor could remove wax which the steam extractor was unable to remove, some slumgum from the Swiss extractor was put in solar extractor number two and heated for four days. The weather was very warm and at the end of the fourth day there was not a trace of wax to be seen in the extractor.

Honey. A number of experiments were made to see if the solar extractor could be used to remove honey from the comb. In the experiments conducted with the dark comb in warm weather, the honey obtained was dark and thick, had a scorched taste and could not be used for anything except feeding purposes. In the other experiments with light colored comb and with moderately bright sun the honey was light colored and of good quality.

Soaking Comb in Water. Some beekeepers make a practice of soaking the comb in water before putting it in the solar extractor, supposing that the soaking loosens the cocoons and dirt in the comb. Some number two comb was soaked in water for six days and put in solar extractor number one. Some comb which had not been soaked was used as a check, and the soaked comb showed an average increase of about one per cent. over the unsoaked.

Comb Soaked in Dilute Sulphuric Acid. It was thought that the soaking of the comb in dilute sulphuric acid might loosen the dirt and

cocoons and leave them in a free condition. Some number two comb was soaked for three days in a solution of five per cent. sulphuric acid, washed to remove the acid and treated in solar extractor number one for three days. Some comb which had not been soaked was used as a check, and the comb treated with acid gave on an average about five per cent. more wax than that not treated. Care had to be taken to wash all of the acid out of the comb before it was put in the extractor on account of the action of the acid on the metal linings of the extractor.

STEAM EXTRACTORS.

In determining the efficiency of the steam extractors three kinds were used, the Ferris, the Root-German, and the Swiss. The Ferris extractor was loaned to the department by Mr. M. A. Gill of Longmont, Colorado, and the Root was loaned by Mr. R. C. Aikin of Loveland, Colorado. The Swiss was obtained from the Station Entomologist.

The Root-German Extractor. This extractor was made by the A. I. Root Co., Medina, Ohio, and consisted of a small sheet iron tank or can with a false bottom. On an iron frame above the false bottom rests a wire basket. Pressure is applied by means of a screw which runs through the cover of the machine. Water is placed in the bottom and the machine placed on a stove. The steam, as it generates, rises through a hole in the middle of the false bottom, which is covered by a deflector. The comb, not too much, is placed in a burlap bag and the bag is placed in a metal basket which is put into the extractor. When the comb becomes thoroughly melted pressure is applied by means of the screw, increasing at intervals and not applied all at once. After most of the wax has been removed it is a good thing to remove the pressure, stir the slumgum and press again. With old comb it is best to stir and press at least two or three times. This extractor worked in a very satisfactory manner and the results show the efficiency of the Root extractor to be greater than that of any of the other steam or solar extractors.

The Ferris Steam Wax Extractor. This extractor was invented by Mr. C. C. Ferris of Richfield Springs, New York, and was the first extractor put on the market which used pressure in connection with steam as a means of extracting beeswax. The extractor consists of a galvanized iron tank in which are suspended two extra heavy galvanized wire-cloth baskets. Comb is placed in the baskets, water is put in the lower portion of the machine and the whole is placed on the stove. The steam as generated, passes upward into the baskets and melts the wax which runs down the inclined bottom and out the spout into a pan containing water. After part of the wax has melted pressure is applied in the basket by means of a screw and the wax is forced out of the comb while it is kept hot by steam. The comb is then stirred, heated and pressed again.

The Ferris extractor worked very well on number one comb, but it did not give good results with either comb numbers two or three. The machine was not made strong enough so that sufficient pressure could be applied to force all of the wax out of the comb. The screws for applying the pressure were too small and the method of fastening them not

very secure. The results show that on an average the efficiency of the Ferris extractor is about one per cent. below the Root extractor for number two comb and about twelve per cent. below for comb number three.

The Swiss Steam Wax Extractor. This extractor is made in two sections. The lower one is an ordinary can and contains water. The upper section has a bottom in the shape of an inverted funnel and rests on the lower one. Inside the upper section is placed a basket made of galvanized wire-cloth. The wax is placed in the basket and the machine placed on the stove. Steam is generated in the bottom, passes up through the hole in the center of the funnel shaped bottom of the upper section and comes in contact with the comb in the basket. The wax in the comb melts and runs down and out of a spout into a pan containing water. The Swiss extractor was used without pressure and the result shows an increase in efficiency caused by the use of pressure in wax extraction. The Swiss extractor can be used in connection with a press by putting the comb in a sack and transferring it to the press, but this method gives the wax a chance to cool and is not as efficient as some of the others.

Remelting Test. The results given above are for the wax as it comes out of the extractor. It was thought that it might be well to determine the amount of dirt in the different samples of wax. The wax used was that obtained in some of the preceding experiments with the Ferris, Swiss and solar extractors.

The wax obtained from each extractor was broken into small pieces, the sample thoroughly mixed, and a separate portion weighed and remelted in each of the four extractors. The wax from the steam extractor was allowed to drop from the spout into a dish of water on a water bath. The heat of the water in the water bath kept the wax melted and the dirt settled to the bottom. Owing to the lateness of the season the wax in the pans of the solar extractors did not remain melted. To have the conditions as near as possible the same as in the steam extraction, the wax from the solar extractors was put in a dish on the water bath, heated and the dirt allowed to settle. In both cases the dirt which had settled to the bottom of the cake was trimmed off and remelted over a water bath. This process was continued until all of the dirt was removed. The percentage of clean wax obtained was, for the solar extractor number one, 94.66, the solar number two, 96.19; the Ferris, 96.31, and the Swiss, 94.38.

Pressing Under Water. The comb, with some water, was put in a tub on the stove and the wax allowed to melt, but not to boil. A can was placed under a press and a slatted follower placed in the bottom of the can. Above this was placed a burlap bag and the hot water, melted wax and comb were poured into the bag, the top of the bag folded over, a slatted follower placed on top and pressure applied by means of a screw. After some of the wax had been forced out, the water and wax were drawn off, the pressure relieved, the slumgum stirred, hot water added and pressure applied again. The can, which fits under the press, has two holes which are stopped by corks. One is at the bottom and the

other near the top. By pulling the cork out of the upper hole the wax which has risen to the top can be drawn off and by using the lower hole all of the wax and water can be removed. The whole apparatus must be kept as warm as possible. An inside can with holes in the sides was tried but did not give good results.

In the following, average results are given because in the first two trials some of the wax adhered to the bag and follower. This method proved very efficient, giving about one per cent. more wax than the Root extractor with number two comb and about six per cent. more with number three comb. The main points in this method were received from Mr. Gill of Longmont, Colo., whose method is somewhat similar except that in his case the wax was dipped from a boiler and placed in the press.

Sulphuric Acid and Pressure Under Water. It was thought that the addition of acid to the water in the experiment might increase the efficiency of the method. The comb was heated in a porcelain lined tub with a solution of five per cent. commercial sulphuric acid. When the wax had melted it was poured into the sack in the press and pressure applied quickly in order not to have the acid in contact with the metal any longer than necessary. The wax and water were drawn off, boiling water added, the slumgum stirred and pressure applied again. This water was drawn off and put with the rest. As this was an experiment to determine the efficiency of the press a tin can was used, but in practical work it would be necessary to have everything acid proof, as hot acid even when diluted, is very destructive to most substances. The can could be made of wood or porcelain lined ware. The latter would probably be the better.

This method was easy to manipulate and rapid and was the most efficient of all the methods used. This method gave about seven per cent. more wax for number two comb and seven per cent. more for number three comb than did the Root extractor.

Comparison of Different Methods. The following table shows the efficiency of all methods with combs number two and three and are average results. Number one comb was not used in all the extractors because most methods give good results with new clean comb:

	Result in Percent.	
	Comb. No. 2	Comb. No. 3
Solar extractor, single glass	31.02	10.24
Solar extractor, double glass	38.27	12.79
Swiss steam extractor	48.59	21.30
Ferris steam extractor	58.02	25.60
Root steam extractor	59.43	37.83
Pressure under water	60.55	44.42
Pressure under water with sulphuric acid	67.02	45.19

COLOR OF THE WAX.

The wax produced by the Root, Ferris or Swiss extractor did not have a good color and would have had to be refined before it could be used. The wax from the solar extractors was always a better color than

that from the steam extractors. The wax formed by pressure under water was nearly as good in color as the wax from the solar extractors. The wax obtained by pressure under water containing five per cent. of sulphuric acid was very good in color, in fact, almost as good (with combs number two and three) as most of the wax obtained from the solar extractors.

I believe the color of the wax from the steam extractors to be due to the presence of iron, owing to the metal in the extractor coming in contact with the steam. The wax from the Ferris and Root extractors was tested and showed the presence of small quantities of iron; enough perhaps to account for the color. The wax from the solar extractors did not show the presence of any iron.

Bleaching Wax. In a search for a method for bleaching beeswax I found many compounds which would effectually bleach the wax, but most of them either destroyed the wax or were in themselves poisonous. Chlorine, which is a great bleaching agent, cannot be used on account of its forming, according to Allen, chlorination substitution—products which may give rise to hydrochloric acid. Beeswax can be volatilized almost without change in a vacuum but when distilled under ordinary pressure it yields a variety of products. Therefore this method cannot be used in purifying beeswax.

The principal use of beeswax is in the manufacture of comb foundation which is given to the bees to act as a foundation on which to build their comb. In order to get nice, white honey the foundation must be light colored. The following experiments were made to determine the best method for cleaning and bleaching wax.

Acids Used in Bleaching. The beeswax on which this experiment was made was a sample of wax that had been rendered from dark colored comb. It was heated in water so as to get a uniform cake, which was cut into eight equal pieces and one piece taken for each test.

Piece number one was heated with 2 cc. of sulfuric acid and 200 cc. of water. Piece number two was heated with 2 cc. of hydrochloric acid and 200 cc. of water. Piece number three was heated with 2 cc. of nitric acid and 200 cc. of water. Piece number four was heated with 200 cc. of water. Piece number five was heated with 200 cc. of water and 2 cc. of a solution containing 60 cc. of sulfuric acid and 63 grams of potassium bichromate to 1000 cc. of water. Piece number six was heated with 200 cc. of water and 5 grams of sodium chloride or common salt. Piece number seven was heated with 100 cc. of the solution of sulfuric acid and potassium bichromate which was used with number five, mixed with 200 cc. of water. They were all cooled in the air and stood over water while cooling. Number one gave the best results and the wax was lighter colored than any of the others. Numbers two, three, five and six did not show much improvement over number four which was used as a blank for comparison. Number seven gave a very dark green wax.

This would go to show that as far as bleaching and removing the coloring matter, the sulphuric acid gives the best results of the materials used.

Sulphuric Acid and Hydrogen Peroxide. For this experiment a sample of dark wax which had been obtained from brood comb was used.

It was melted in hot water, formed into a cake, the cake cut in eight equal pieces and the pieces treated in the following manner:

Piece number one was heated with 100 cc. of water.

Piece number two was heated with 100 cc. of water and 2 cc. of sulfuric acid. Piece number three was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number four was heated with 100 cc. of water, 10 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number five was heated with 100 cc. of water, 15 cc. hydrogen peroxide and 2 cc. of sulfuric acid. Piece number six was heated with 100 cc. of water, 20 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number seven was heated with 100 cc. of water, 25 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Piece number eight was heated with 100 cc. of water and 5 grams of oxalic acid. Piece number three, heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc of sulphuric acid, was much better than any of the others. Hydrogen peroxide was tested for and found in the water in which the wax had been melted. Excessive boiling with water seemed to injure the grain of the wax, but the heating with water and sulfuric acid and with water, sulfuric acid and hydrogen peroxide did not seem to injure the grain. Piece number eight showed only a slight improvement over the original sample.

Remelting with Sulphuric Acid and Hydrogen Peroxide. One-half of piece number three of the last experiment was remelted in 100 cc. of water, 2 cc. of sulfuric acid and 5 cc. of hydrogen peroxide. The color of the wax was very much lighter than before being remelted in 100 cc. of water, 5 cc. of hydrogen peroxide and 5 cc. of sulfuric acid. The wax was pressed out of the cloth and was very much improved. It had a golden yellow color and a good grain.

Increasing the Amount of Sulfuric Acid. The wax used in this experiment was dark and was obtained by rendering old combs. It was remelted and divided into eight equal parts. Number one was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid. Number two was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 5 cc, of sulfuric acid. Number three was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 10 cc. of sulfuric acid. Number four was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 15 cc. of sulfuric acid. Number five was heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 20 cc. of sulfuric acid. Number six was the same as number five except that it was heated with 25 cc. of sulfuric acid. Number seven was inclosed in a canton flannel bag, heated with 100 cc. of water, 5 cc. of hydrogen peroxide and 2 cc. of sulfuric acid, and the wax squeezed out of the bag. Number eight was heated with 100 cc. of water. Number two gave better results than any of the others with the exception of number seven, which gave a very nice yellow wax.

Refining with Alcohol. The wax taken for this experiment was obtained by rendering old brood combs and was dark. It was remelted and divided into eight pieces. Number one was heated on the water bath with 100 cc. of barrel alcohol. Number two was heated on the water bath with 50 cc. of alcohol and 50 cc. of water. Number three was heated in the same manner as number two with 25 cc. of alcohol and 75 cc. of water. Number four, one-fourth of number one, was heated in water. In number one the wax dissolved and on cooling cerotic acid separated from the alcohol. In numbers two and three there did not seem to be any cerotic acid dissolved in the liquids. Number one gave a soft waxy substance, probably myricine. Number four gave a compact substance. Number five was as good in appearance and texture as any of the others. I could not see any improvement in the color of the wax caused by the treatment with alcohol.

The use of Cloth in Refining Wax. The wax used for this experiment was very dark and was divided into four equal parts. Piece number one

was inclosed in a piece of fine canton flannel cloth and heated in water which contained five per cent of sulfuric acid and five per cent of hydrogen peroxide. Number two was inclosed in a piece of fine canton flannel and heated in a solution of five per cent sulfuric acid. Number three was inclosed in a piece of coarse linen cloth and heated in a solution containing five per cent sulfuric acid and five per cent hydrogen peroxide. Number four was inclosed in a piece of fine canton flannel and heated in water. Number one gave the best results. The wax had a good color and a good grain. Number two was next to the best. Number three was not as good as either number one or number two. Number four was used as a check. All showed improvement over number four.

One-half of number one was placed in a canton flannel cloth and heated with a solution containing five per cent sulfuric acid and five per cent hydrogen. One-half of this last sample was placed in a canton flannel cloth and heated twenty minutes with a solution containing two per cent sulfuric acid and five per cent hydrogen peroxide. Three-fourths of the last sample was placed in a canton flannel cloth and heated with a solution containing five per cent hydrogen peroxide and two per cent sulfuric acid. The last sample was remelted in the same manner and the color could not be improved. The last two heatings did not seem to improve the color of the wax. The one before them, number two, gave the best colored wax and the wax had a good grain.

EXAMINATION OF THE SLUMGUM.

As stated under the properties of wax, the wax contains on an average of about 14.4% cerotic acid. There are two ways known for the determination of pure wax in impure beeswax. They both depend on the amount of cerotic acid in the wax which can be saponified in the presence of wood alcohol. Neither method is very satisfactory for dark colored wax. The amount of cerotic acid in the slumgum might be determined by one of these methods and the amount of wax in the slumgum estimated.

All of the slumgums gave cerotic acid and therefore contain some wax. I was unable to devise any method or modification of methods to determine the amount of cerotic acid in the slumgum. In the presence of so much coloring matter the indicators did not give good results.

Boiling with wood alcohol and decanting off the hot solution and titrating was tried, but was unsatisfactory. It was found that after boiling ten grams of slumgum with twelve portions of wood alcohol of 50 cc. each there still remained cerotic acid in the residue. The addition of hydrogen peroxide to the alcohol and slumgum did not cause an improvement. A red coloration was formed which covered the end reaction of the indicator.

SUMMARY.

In summing up the facts given in the preceding experiments, I draw the following conclusions:

In some ways the solar extractor is a good extractor for the beekeeper to have. It is convenient and requires very little attention. The solar extractor does not remove as much wax from the comb as the steam extractor. The residue, or slumgum, from the solar extractor may be worked over in the steam extractor and some wax obtained. The solar extractor can remove honey from the comb, but with ordinary comb and warm weather the honey is not of a very good quality.

The heat of the sun seems to bleach some kinds of wax, besides extracting it from the comb. In other cases it is difficult to notice any bleaching in wax which is exposed to the sun.

The steam wax extractor removes more dirt than the solar extractor. The steam extractor will remove honey from the comb, but the honey is usually very dark. In efficiency the steam extractor has an advantage of from ten to twenty per cent over the solar extractor.

In efficiency the solar wax extractor number two has a slight advantage over solar extractor number one, about one per cent for number one comb, for number two comb two per cent, and for number three comb about one per cent.

The addition of an extra pane of glass to the solar extractor raised the inside temperature on an average of 17 degrees F. The efficiency of the extractor was increased on an average about seven per cent. for number two comb and two per cent for number three comb.

The addition of a lamp to the solar extractor raised the efficiency of the extractor on an average about one per cent.

The addition of a lamp to the double glass extractor did not increase the efficiency of the extractor over 0.7 per cent.

Soaking the comb in water before using the solar extractor increased the yield of wax on an average, about one per cent.

The soaking of the comb in dilute (5 per cent) sulfuric acid increased the yield about five per cent over that not treated.

Of the steam wax extractors, the Root proved the best. The results show that for the same comb, number two, the Root produced one per cent more than the Ferris and ten per cent more than the Swiss.

Pressure applied to the comb under hot water gives a larger per cent wax than when the comb is pressed in steam. Heating with dilute sulfuric acid and pressing under water gave the best results. For number two comb this method excells in efficiency the single glass solar extractor by thirty-six per cent., the double glass solar by twenty-nine per cent., the Swiss steam wax extractor by eighteen per cent, the Ferris steam wax extractor by nine per cent, and the Root steam wax extractor by over seven per cent.

For number three comb, heating with dilute sulfuric acid and pressing under hot water, excells the single glass solar wax extractor by thirty-five per cent, the double glass solar wax extractor by about thirty-two per cent, the Swiss steam wax extractor by twenty-four per cent, the Ferris steam wax extractor by nineteen per cent, and the Root steam wax extractor by seven per cent.

The above shows that the slumgum from 100 pounds of wax treated by the ordinary solar wax extractor will retain from thirty-four to thirty-six pounds of wax, which can be removed by heating with dilute sulfuric acid and pressing under hot water. If the Root extractor, which is the best

of the steam wax extractors, is used there remains in the slumgum about seven pounds of wax which is obtainable by the use of the sulfuric acid and pressure. With the price of wax at twenty-five cents a pound it would pay to buy old slumgum and remove the wax by this method.

The method of heating the wax, while inclosed in a bag, with sulfuric acid, as practiced by some refiners of wax, gives good results.

Sulfuric acid seems to be better for bleaching wax than either hydrochloric acid, nitric acid, or a mixture of potassium bichromate and sulfuric acid. The wax from the latter has a dark green color which may be removed by repeated heating with oxalic acid. Oxalic acid is a poison and I am not prepared to state how much would be left in the wax or what effect it would have upon the bees working with the wax.

An increase of sulfuric acid above five per cent does not seem to improve the color of the wax.

The addition of five per cent of hydrogen peroxide to the sulfuric acid and water gives a much lighter colored wax. An increase of hydrogen peroxide above five per cent does not give an improvement in the color of the wax.

Common salt added to the water in which the wax is boiled does not cause the dirt to settle enough to show a change in the color of the wax.

Heating the wax, which has not been treated with sulfuric acid and potassium bichromate, with oxalic acid does not seem to improve the color of the wax.

Excessive boiling seems to injure the grain of the wax. The best results in regard to the grain of the wax were obtained by causing the wax to melt but not come to a boil.

Heating the wax while inclosed in a cloth and squeezing it after the wax has melted gives a much better colored wax than heating without the cloth. A fine canton flannel cloth with the nap inside is better than a coarse cloth. The nap seems to hold the dirt that is in the wax. Remelting the wax inclosed in a cloth with two per cent. solution of sulphuric acid and five per cent. hydrogen peroxide improves the color of the wax. Continued treatment in the same way does not give corresponding improvement in the color of wax. After the third treatment there is not any improvement in the color and rather a deterioration in the quality of the wax.

Boiling with concentrated and dilute alcohol does not improve the color of the wax.

The color of the wax is not improved by standing over water after cooling.

All of the slumgum retains some wax, but it was found impossible to determine the exact amount.

From the results of these experiments and my own experience in handling bees and rendering wax I believe that it is best for the average beekeeper to have a large solar wax extractor, heated by some artificial heat, by means of which most of the wax in the lighter colored combs, cappings, and burr combs may be easily rendered. The dark combs may also be treated in this manner and the slumgum stored in barrels until the beekeeper has time to treat it with dilute sulphuric acid and press under water. This method is quick and efficient. If the wax has to be refined it can be done by heating, while inclosed in a canton flannel sack, with a solution containing five per cent. of hydrogen peroxide and two to five per cent. of sulphuric acid. Both of these chemicals can be bought at the ordinary drug store. The common kind, commercial, should be used.

In mixing the acid and the water care should be taken to always pour the acid gently into the water and not the water into the acid.

The cost of the chemicals compared with the results obtained is very slight.

Bulletin 130 May 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

The Evergreen Trees of Colorado

BY

B. O. LONGYEAR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915

GOVERNOR HENRY A. BUCHTEL,
PRESIDENT BARTON O. AYLESWORTH, } *Ex-Officio.*

A. M. HAWLEY, SECRETARY — CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*,	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.,	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
W. H. OLIN, M. S.,	AGRONOMIST
W. G. SACKETT, B. S.,	BACTERIOLOGIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOUGLASS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S.,	ASSISTANT ENTOMOLOGIST
B O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S.,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS
MIRIAM A. PALMER,	ARTIST
L. C. BRAGG,	ASS'T IN ENTOMOLOGY

STATE FRUIT INVESTIGATIONS

O. B. WHIPPLE, B. S., GRAND JUNCTION,	FIELD HORTICULTURIST
GEORGE P. WELDON, B. S., DELTA	FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

THE EVERGREEN TREES OF COLORADO

By B. O. LONGYEAR

At no time in the history of our country have matters pertaining to our forests been of such general interest as at the present. Such interest is certainly justified when we consider the fact that between three and four times as much timber is used by us each year as our forests can grow in the same length of time. Many of the materials which a few years ago were expected to become substitutes for wood have failed to meet the requirements in many ways. Moreover the continued use of wood for new purposes more than offsets the saving by these substitutes. Hence there is not only apprehension for the future supply of wood but even now certain great industries are being forced to limit their operations because of the scarcity of timber. This is particularly true of the timber from which paper pulp is manufactured.

In Colorado the principal drains upon the timber resources of the state have been to supply material for mining timbers, telegraph poles, railroad ties, fence posts, bridge timbers and native lumber. The growing scarcity of our timber trees is being emphasized by the rapid advance in price which is now felt in all industries requiring such material.

So long as the forests have been left to the disposition of private interests the forests have suffered greatly. The wasteful and careless methods of lumbering that have usually been employed in this country have frequently been followed by the consuming fire fiend. In these ways the larger part of our forest products have often failed to reach the markets but have served to darken the skies with the smoke of a sacrifice in which the gods have no pleasure. Not only have the trees themselves been destroyed but in many cases the burning away of the humus, the slow accumulation of centuries, has laid bare the very rocks and made reforestation impossible. But this is not all. The rapid and complete removal of the forests has in many places shown how great was their influence upon water movements. Thus with the removal of the forests that once surrounded the headwaters of our great streams, disastrous floods in spring and low water in summer have indicated the regulating effects which these forests once produced. In our own state the forests in the higher altitudes serve to check in spring the rapid melting of snow which has drifted among the trees and thereby lengthen the period of stream flow during the growing season.* The most important effects of the forests in this connection, however, are due to the character of the forest floor, which is

* For some of the effects see Bulletin 55, Colo. Exp. Sta.

composed of the decayed, castoff parts of the trees themselves. This layer of humus material possesses the ability to absorb water like a sponge and in this way check the rapid surface flow of water such as takes place on bare soil. Thus the water from melting snows and from heavy rains is held back to appear later from springs instead of rushing into the streams and giving rise to floods and high water.

NATIONAL FOREST RESERVES.

The extent of the forest reserves in this country indicates the importance which the government places upon the conservation of the forests. The first national forest reservation was established in 1891. On April 1, 1907, the total extent of the forest reserves in the United States comprised one hundred and fifty-three reserves with a grand total of nearly one hundred and forty-eight million acres. California stands at the head of the list with an area of nearly twenty-two million acres, while Colorado comes fifth with eighteen reserves covering nearly sixteen million acres. These vast tracts have not been set aside, however, to become unproductive holdings of the National Government. They are not even closed to the would-be settler on any agricultural lands within their boundaries nor to the prospector and miner in seeking and developing claims. Grazing lands within the forest reserves can still be used as such with the added protection to the industry which the small fee carries with it. Neither is it the primary object of the forest reserve idea to stop the cutting and sale of timber but to regulate it in such a way as to make the forests more productive. In fact, the primary purpose is to prevent wasteful and destructive practices of lumbering, to protect the forests from fire, their most destructive enemy, and to get them in a condition where reforestation may go on and thus make them a perpetual source of timber supply.

The principal forest trees of this state are those commonly known as evergreens. It is the purpose of the present bulletin to help familiarize the people of this state with our native evergreen trees and thereby strengthen the interest in their protection. Brief suggestions and directions are also given for their use in ornamenting the home grounds and in planting for wind-breaks and screens.

THE EVERGREENS.

In popular usage the term evergreen is applied to members of the pine or cone-bearing family of trees. This is due to the fact that most members of this family hold each season's crop of leaves during several years so that at no time are they bare of foliage. Some true cone-bearing trees, however, such as the larches, shed all their leaves each autumn the same as other deciduous trees. On the other hand, some of the broad-leaved trees and shrubs hold

their foliage in a green state over winter or even longer and are therefore true evergreens. This is particularly the case in tropical countries. But as all the cone-bearing trees of this state are evergreens the term as here used is intended to include members of the pine and juniper families only.

The plants of the pine family are chiefly characterized by the fact that their seeds, instead of being contained during all stages of growth in wholly closed seed cases, as in other seed-bearing plants, are at first born naked on the scales of cones. The scales of these cones become dry and more or less woody and hard according to their thickness and form the familiar dry, scaly cones of such trees.

Another character common to the plants of the pine family in this region is found in their needle-shaped leaves. These leaves, on account of the relatively small surface which they expose and the thickness of the epidermis which covers them, are well adapted to endure the drying effects of winter so trying to all kinds of perennial plants.

Most of the cone-bearing trees are possessed of a resinous juice or sap which often exudes from wounds and slowly hardens in the form of drops or masses of pitch. This material, when gathered from certain pines in the southeastern states, constitutes the crude turpentine from which the spirits of turpentine of commerce is obtained, the common resin or rosin being left as a residue. Timber from pine trees in which the wood has become saturated with the pitch of the sap possesses great durability in contact with the soil.

In most species of cone-bearing trees the two sorts of flowers, which are separate, occur on the same trees. The stamen flowers, those which produce the pollen, are crowded in small catkins or cone-like clusters near the ends of the branches. (Plate II, 1.) The pollen, in the form of a yellow powder, is abundantly produced and is carried by the wind to the young pistillate or seed-bearing cones. In the vicinity of extensive spruce and pine forests this pollen powder is often so abundant, during the blossoming period, as to lend the impression that a shower of sulphur has occurred. Soon after the pollen is shed these little cones dry up and fall off, hence are not commonly noticed.

The pistillate or seed-bearing cone consists of an axis upon which are fastened the scales. The scales vary much in shape and texture in different species and furnish some of the principal characters by which the species are distinguished. At the base of each scale of the young cone, and lying attached to its upper surface, is a pair of ovules. During the flowering period the young cones point upward with the scales spread apart. This allows some of

the pollen grains, with which the air may be filled at this period, to slip down to the base of the scales, where they come in contact with the waiting ovules. In a few days the scales close together and the process of fertilization later takes place. This is soon followed by the growth in size of the cones and the development of an embryo within each ovule by which it becomes a seed. (Plate I and II A.)

In some species, e. g., the pines, the scales of the cones remain closed during the whole of the first year and mature their seeds in the second year. In others, such as the spruces, the seeds are matured and dropped at the end of the first season.

In the juniper family, which is closely related to the pine family, these seed-bearing scales become fleshy and united as the cones ripen so that the matured seeds are found imbedded in the pulp of the berry-like fruits.

TRANSPLANTING EVERGREENS.

The root system of the cone-bearing trees is often very extensive, especially in trees that have reached some age, and have grown all their lives undisturbed as in nature. The roots are, moreover, very sensitive to drying and, on account of the resinous character of the sap, when once dry they cannot be revived by soaking. Then, too, an evergreen always has leaves which are continually giving off some moisture, hence at no time can these trees be without moisture at the roots without suffering injury. These facts usually account for the lack of success which so many persons experience in transplanting evergreens. The writer has seen young evergreen trees that had been carelessly dug or even pulled from the soil among the hills, where they had become deeply rooted, and then carried for miles with no protection whatever to the roots. A cottonwood, boxelder or black locust might survive such treatment, but an evergreen should never be expected to grow when handled in this manner.

USE OF FOREST GROWN SEEDLINGS.

The fact that the roots of evergreens are usually slender and that they quickly extend with but little branching to considerable distances, when undisturbed, makes the transplanting of forest grown trees an uncertain matter. This is especially true when trees of some size are being moved by the usual methods. Native forest seedlings are, however, often made use of in forest planting and the same can be done for other uses providing that the small seedlings only are moved. The best time for this work is just as the buds are beginning to swell in spring but before the new growth is out. Somewhat later transplanting can, however, be done with extra care. Such seedlings should not be over ten inches in height

to bear transplanting well, and smaller sizes are better. They should be carefully lifted from the soil with a spade in such a way as to retain as many of the roots as possible. A pail or tub with two or three inches of thin mud or puddle in the bottom should be at hand, into which the roots of the little trees are to be at once placed. If they are to be planted again in a few hours the seedlings may be carried in this condition. But where large numbers are being gathered and where a considerable journey is necessary, the trees may be closely packed, roots down, in boxes, using moist sphagnum moss, fine grass or similar material among the roots. The boxes should be covered, if placed in an open vehicle, for the journey. If the trees are not to be planted out at once they may be heeled in for a few days. This consists of placing the roots in a broad trench with the trees leaning against one side, after which moist soil is shoveled over them until the trees are about half buried. A shady place should be selected for this purpose.

Trees of such small size are usually grown for two or more years in nursery rows or until one to two feet high. In this way they can usually be given much better care than when placed in the wind-break or other permanent quarters. They should be planted in rows about eighteen inches apart and six to eight inches apart in the row for the small sizes.

Transplanting is best accomplished by laying a wide board upon the surface of the soil and then opening a trench along one edge with a spade. The little trees are then planted against the perpendicular side of the trench and moist soil firmly packed about the roots. The trench should be made only a few minutes before planting to avoid drying of the soil, and the trees should be carried in a pail containing a little water. If possible, select a cloudy day for this work and when the soil is moist but not wet. The soil should not be allowed to bake at any time. Careful cultivation must be maintained during the earlier half or two-thirds of the growing season and a winter mulch of coarse manure or straw is desirable.

In transplanting larger trees the same care must be observed as with small ones. It is often possible, in moving them only a short distance, to retain the earth surrounding the roots in a ball. Thorough packing of the soil about the roots should be practiced except where the soil is very sticky or wet.

It is usually desirable to give the nursery partial shade during the first season. This may be accomplished by lath screens supported on stakes about one foot high. Brush laid across wooden bars or wires stretched along the rows may also be used.

NURSERY GROWN STOCK.

This is always to be preferred where only a few trees are

wanted and where one has no time to grow them from seedlings. Nursery grown trees, if properly handled, have been transplanted one or more times. This causes the root system to thicken up, or become condensed in a relatively small space, and thus makes it possible to secure practically all of the roots in a compact mass when dug. Some nurserymen, who make a specialty of growing evergreen stock, furnish trees each with a ball of earth which contains most of the roots and enables one to plant them with confidence. Trees up to eight feet in height may in this way be safely shipped and transplanted, but, of course, they are correspondingly expensive.

Nursery grown seedlings four to ten inches high and one to three years old can be purchased in quantity from the leading nurserymen and are often cheaper than forest grown seedlings if one considers the time and labor required to obtain the latter. Nursery grown stock, whether in seedling or larger sizes, is usually cheaper in the end than forest trees for, not only are the trees more apt to live, but, having been adapted to conditions in the open, they are surer to make a rapid and healthy growth.

THE PROPER TIME TO TRANSPLANT EVERGREENS.

It is generally recommended that evergreens are best transplanted in spring. This is particularly the case in a climate like that which prevails in Colorado. Fall planting is claimed to be satisfactory by some nurserymen and it may prove successful in other climates. But the lack of soil moisture which often prevails here in the winter season, together with the drying winter winds, makes fall planting a very hazardous undertaking. Trees of this class will often bear later transplanting than other kinds. The proper time, however, is when the buds are swelling, as at this time the vital processes of the tree are just commencing. Hence new root growth is taking place which will enable the tree to secure water from the soil and to become established.

PRUNING.

It is seldom necessary to prune carefully dug nursery grown evergreens, when they are transplanted, unless it is desired to change their shape. The same is true of seedling trees, even forest grown.

In transplanting forest grown trees of more than one foot in height it may be desirable to cut back the limbs one-third to reduce the loss of moisture from the leaves.

It is best to preserve the terminal bud, as this gives rise to the leader or main stem. If by any means this bud is destroyed it sometimes occurs that two or three of the next lower whorl of buds will push up equally strong shoots. In this case all but one should

be pinched back or cut off and the remaining one be tied erect to the stub of the leader.

EVERGREENS ON THE LAWN.

Among the evergreen trees of Colorado are to be found some of our most ornamental trees for the home grounds. If rightly placed and properly planted so as to secure a healthy growth they are capable of adding, not merely to the foliage effects of summer, but they also lend a pleasing touch of green to the winter landscape.

They are best situated along the borders of the grounds, where they may form a background for shrubs and flowering plants. Specimen trees should not be freely used, as a rule, except on large grounds. They should be placed at a sufficient distance from other trees so that they can spread out naturally. If planted in sodded ground the sod should be removed and a circle of bare earth four or five feet across, kept well cultivated around each tree for several years. A great many evergreen trees, as well as other kinds, are needlessly lost every year by planting them in sod where they must compete with the grass.

In the pruning of old trees one should hesitate to cut off the limbs close to the trunk if it is expected that new ones will start out as in many of the deciduous trees. The usual manner of pruning evergreens up from the ground for several feet is much to be deplored, especially in the case of specimen trees on the lawn. The beauty of most evergreens in such situations is dependent on their being allowed to develop a natural form with the lower branches extending clear to the ground. This practice of trimming off the lower branches is most often due to planting evergreens where they eventually shut off the light or the view. Thus it is advisable to plan well in advance the position of each tree about the house and to take into account the effects of future growth. If trees of this class are planted on the south side and close to the dwelling there will eventually be an undesirable shading of the house in winter on the side where the sunshine at that season is most available.

Then, too, the planting of evergreens before the front windows is sure in time to give rise to the necessity of trimming the trees up from the bottom, removing them entirely or else leaving them to darken the rooms and obstruct the view. Where privacy and seclusion are sought, however, evergreens are well suited to such purposes. Thus they may be used to screen or hide unsightly places or objects and are splendidly adapted for planting around outbuildings.

EVERGREENS FOR WINDBREAKS.

Evergreens are among the most effective trees for windbreaks. They are especially desirable for giving shelter from cold winds in winter to sheds and barns and yards for stock. They are also desirable to plant around the outside of the deciduous timber plantation to check the sweep of winds which carry away the snow and fallen leaves. Seedling trees which have been twice transplanted and are about one foot high are of a suitable size for this purpose. They should be set far enough apart to allow each tree to spread out without crowding and eventual loss of the lower limbs. Eight or ten feet apart is about as close as such trees as pines and spruces should be planted. If more than one row is used the trees should alternate in the rows and the rows be at least twelve feet apart. Where a low hedge-like effect is desired much closer planting may be done, and the trees cut back when at the proper height.

Thorough cultivation is needed until the trees are well established or as long as there is sufficient room between the rows.

Evergreens can often be established with good results among deciduous trees planted for windbreaks. In fact, many species of evergreens cannot be readily grown during the seedling stages except in partial shade, hence the desirability of shading the young plants in the nursery.

Close shading, however, should not be allowed to continue after the trees have reached a height of four or five feet. Otherwise the trees are apt to lose their lower branches and become spindling, thus greatly reducing their effective windbreak character. If the surrounding trees become too tall and dense they should be thinned out or cut back to give the slower growing evergreens a better chance.

RAISING EVERGREENS FROM SEED.

This is work which is most successfully undertaken by nurserymen or other persons of experience. For those who have time and the necessary patience to wait for several years while the seedlings are growing this is not only a cheap way to secure a large amount of stock, but is also very interesting work. Seeds of most evergreens can usually be purchased from the large seed houses. Where possible, however, it is desirable to save them from native or local growing trees which show the best color, form and hardiness. Seeds of the pines and spruces are best harvested by gathering the cones a little while before they open. When dry, in most cases the scales spread apart and allow the seeds to be readily threshed out. The cones of the lodge pole pine, however, often do not open unless heated to 100 to 150 degrees

Fahrenheit. This may be done on a wire screen placed above a stove, or in an oven.

In the case of junipers and red cedars the berries when ripe should be gathered and soaked for twenty-four hours in strong lye made from wood ashes, and rubbed on a fine sieve to remove the pulp. They should then be stratified by mixing them with moist sand which is to be kept in a box or other receptacle left where freezing will take place. They will not usually grow until the second season.

The seed bed for raising conifers should be on light, porous soil with good underdrainage, but which can be kept from drying out. If only a small number are to be grown good garden soil can be suitably prepared by mixing a considerable proportion of fine sand with the surface two or three inches. If the soil is naturally sandy this would not be necessary.

Beds about four feet wide may be laid off and the seeds sown broadcast or in drills or rows, scattering them about as thickly as with radish or onion seed, for the smaller kinds, and about one inch apart for the larger kinds. The planting is usually done in May, the seeds being covered to a depth of ¼ to ½ inches, depending on their size.

If the soil is at all heavy or loamy in character a layer of fine sand should be scattered over the bed to a depth of one-fourth inch. The soil should be moist but not wet when the seeds are sown and the surface must be kept finely pulverized. Where the atmosphere is very dry it is often possible to retain the soil moisture by covering the beds with burlap fastened down with pegs. This will admit the sprinkling of the beds with a watering pot without washing the soil or disturbing the seeds. The burlap covering must be removed as soon as the seedlings begin to break through the soil.

Most evergreens require partial shade during the first two or three years of growth from seed. This is usually accomplished by means of lath screens placed six feet above the beds, the lath being laid about one and one-half inches apart. In place of lath brush may be used laid on a framework of poles supported on posts of the proper height. Although free circulation of air must be given across the evergreen seed bed the seedlings should be protected from strong winds either by lath screens or by brush stuck firmly into the ground around the sides of the bed. Boards ten or twelve inches wide set on edge around the edge of the beds will furnish excellent protection from surface wind-sweep and consequent rapid drying out of the soil.

An excellent plan to follow in raising coniferous seedlings is to inclose the seed beds with twelve-inch boards placed on edge,

making the beds four feet wide and as long as desired. The soil within the bed should be one or two inches higher than that outside the frame. After the soil is carefully leveled and firmed with a piece of board the seeds are sown broadcast and covered to the proper depth by sprinkling fine soil upon them. Lath screens are then laid across the bed and allowed to rest upon the board frame. In this way trouble from strong winds, which might blow down the high screens, is avoided and moisture is readily retained. On cloudy days the screens should be removed, especially while the seedlings are young.

If an open place among trees and in partial shade is available the artificial screen may be omitted. Care should be taken to keep the surface of the soil comparatively dry, for a wet, soggy soil is almost certain to induce "damping off," a disease caused by certain fungi which thrive in poorly drained soils. A thin layer of pure sand spread over the surface of the soil is often used to check or prevent this trouble.

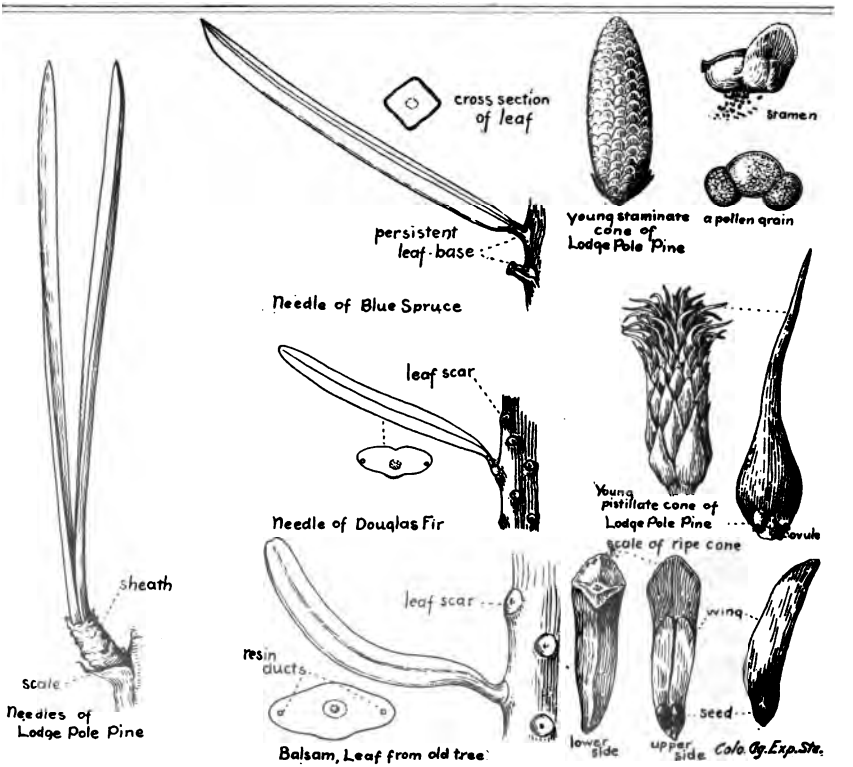


PLATE I.

Drawings showing leaf-characters that distinguish the pines, spruces and firs; also the flowers (young cones) of a pine, all somewhat enlarged.

On the approach of winter the bed of seedlings should be mulched with straw, leaves or evergreen boughs, which will protect the little trees from the injuries of alternate freezing and thawing. In the spring the mulch should be removed a little while before growth begins and careful cultivation with a fine toothed rake be given. At the age of two years the seedlings should be transplanted four to six inches apart in nursery rows as recommended for forest grown seedlings. They will in most cases be too small to transplant to permanent quarters until four years old.

SPECIES OF EVERGREEN TREES IN COLORADO.

The evergreen trees native to this state belong in two families —the pine family and the juniper family. The two families as they occur here may be distinguished by the following characters:

Pine Family.—Foliage leaves needle-shaped; single or in bundles of two to five; fruit a dry, scaly cone; seeds usually furnished with a thin wing.

Juniper Family.—Leaves awl-shaped or scale-shaped, in the latter case entirely covering the twigs; fruit berry-like, juicy or nearly dry; seeds usually without wings.

Of the thirteen evergreens occurring in Colorado which grow to the stature of trees ten belong in the pine family.

Pinaceae—PINE FAMILY.

(Plate I.)

KEY TO THE COLORADO GENERA.

I. Needles in tufts or bundles of two to five, mostly more than 25 m m. (1 in.) long, surrounded at base by a short sheath; cone scales thick, hard and woody when mature.

1. Genus Pinus.

II. Needles single, mostly less than 25 m m. (1 in.) long. Cone scales thin, leathery or papery when mature.

A. Needles in our species stiff and four angled, each one jointed to a short, hard, brownish base; branchlets rough from the prominent leaf bases which remain long after the upper part has fallen; cones pendulous, with persistent scales.

2. Genus Picea.

B. Needles flat, without hard, persistent bases, falling entirely away and leaving rounded scars; branchlets from which the leaves have fallen quite smooth.

a. Needles with a narrowed or stalk-like base, scars small, elliptical across the branchlets; cones pendulous, feathered with projecting, three-pointed bracts.

3. Genus Pseudotsuga.

b. Needles not narrowed at base, scars quite large, circular in outline; cones erect, dark purple or blackish, the scales falling separately from the axis.

4. Genus Abies.

GENUS *Pinus*—THE PINES.

The pines form the most important group of the cone-bearing trees. As indicated in the key they are most easily recognized by the needles being in bundles of two or more with a short sheath at the base. This sheath, together with the needles which it surrounds at the base, grows from a very short twig which arises just above a small, brownish scale that also represents a form of leaf. The staminate flowers occur in small cone-like clusters crowded around the stems at the base of the new growth of the season. After the blossoming, which occurs quite early in the growing season of the tree, the staminate flower clusters dry up and fall off and thus leave a bare space on the branch which bore them. The pistillate or seed-bearing cones appear near the tips or along the sides of the new growth. At first they are small and are usually overlooked. After the blossoming period they develop rather slowly and do not mature their seeds until the second autumn. The scales of the cone are thick and hard and in some species each is furnished with a sharp curved prickle. Two seeds are borne at the base of each scale. As the seed matures a part of the scale peels off wtih the seed and forms its wing.

KEY TO THE COLORADO SPECIES OF PINUS.

I. Needles, five in a bundle.
  a. Scales of the cone tipped with curved prickles.
    1. ***Pinus aristata.***
  b. Scales of the cone without prickles.
    2. ***Pinus flexilis.***

II. Needles two to three in a bundle.
  A. Needles 8-12.5 c. m. (3-5 in.) long.
    3. ***Pinus scopulorum.***
  B. Needles not over 6 c. m. (2⅜ in.) long.
    a. Needles 3-6 c. m. (1¼-2⅜ in.) long; seeds small, 4-5 m m. (5/16 in.) long.
      4. ***Pinus Murrayana.***
    b. Needles 2-4 c. m. (¾-1½ in.) long; seeds large, 10-15 m m. (⅜-⅝ in.) long.
      5. ***Pinus edulis,***

FOXTAIL PINE, HICKORY PINE.

(*Pinus aristata,* Engelm.)

(Plate II B)

The foxtail pine occurs chiefly in the higher altitudes among the mountains of central and southern Colorado, in Utah, Nevada and southern California and Arizona. It is a small or medium sized tree of bushy habit, seldom reaching a height of 12-15m. The short needles grow in bundles of five closely crowded along

PLATE II.

A. Flowers or young cones of lodge pole pine.
1. Staminate flower-clusters.
2. Pistillate cones on new growth.

B. Branch and cone of Foxtail pine.

the branchlets in brush-like tufts. The cones are about 8 cm. long and each scale is furnished at the tip with a slender curved bristle. On the branches of young trees the bark is at first smooth and milky white. On trunks of older trees the bark becomes irregularly divided into small scales of a brownish color. The wood is soft and light and possesses but little strength. It is sometimes used for mine timbers and fuel.

This tree is of but little commercial importance and its slow growth does not recommend it for planting where quick effects are desired.

LIMBER PINE, ROCKY MOUNTAIN OR WESTERN WHITE PINE.

(*Pinus flexilis*, James; *Apinus flexilis*. Colo, Exp. Station Bulletin 100, Rydberg.)

(Plate III.)

The common name of this pine is suggested by the long, lateral branches which are quite stout and enable this tree to survive in the wind-swept situations which it usually inhabits. It is of low topped form and stout trunk and occurs often at high altitudes in rocky, exposed places. The needles grow in bundles of five and are about 5 cm. long. At a little distance this tree resembles the foxtail pine, but is readily distinguishable from the latter species by the cones. Those of the limber pine are composed of numerous rather thin scales entirely free from prickles. The seeds are large and approach in size those of the pinion pine. In fact, this pine is not infrequently mistaken for the true pinon. It is readily distinguished by the fact that the needles of the pinon are in bundles of two instead of five as in this species.

The bark of the young branches and stems is smooth, light gray or white, becoming deeply fissured and dark brown or nearly black on old trunks. The light, soft wood is sometimes used for lumber, but is sure to be full of knots.

The limber pine is quite widely distributed, occurring along the eastern slope of the Rockies from Alberta to western Texas and southern California. Its largest size, occasionally 15-20 m. high, is reached in northern New Mexico and Arizona. In Colorado this pine is scattered throughout the higher portions of the mountains.

The limber pine is adapted to planting as an ornamental tree where large size is not desired.

Its hardy character enables it to thrive under cultivation and when thus grown it forms a tree of compact form and pleasing appearance. It is worthy of a place in the home grounds.

BULL PINE, ROCKY MOUNTAIN OR WESTERN YELLOW PINE, ROCK PINE.

(*Pinus scopulorum* (Engelm.) Lemmon)

(Plate IV.)

This is the largest of our pines and forms the prinicpal evergreen of the foothills and ridges along the mountain ranges and in the mountain parks. Outside this state it occurs in western Nebraska and from Montana to Arizona and New Mexico. On the Colorado plateau this tree forms the most extensive pine forests on the continent. From northwestern Nebraska

PLATE III.
Needles, cone and tree of Limber pine.

LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

PLATE IV.
Trunk, cone and needles of Bull pine.

and western Texas to the Pacific Ocean and from southern British Columbia to southern California and Mexico this pine is replaced by the species pinus ponderosa, of which it is often considered as the variety scopulorum.

In Colorado the bull or rock pine forms rather open woods or forests on the slopes of valleys. Here it grows to a height of 24-30 m. (80-100 ft.) high and 1 m. (40 in.) in diameter. On the exposed rocky ridges and slopes it forms a spreading tree of stocky growth. The dark green needles are in bundles of two to three and vary in length from three to six inches. The cones are two to three inches long and the scales are tipped with stout recurved prickles, which on old cones are often missing. On large limbs and trunks the bark is blackish or cinnamon colored and on old trunks becomes thick and deeply furrowed. The wood is heavy and strong, but differs much in quality and is apt to be quite knotty. Its main uses are for lumber, railway ties and mine timbers.

This pine, on account of its deep growing root system, is able to resist drought better than almost any other of our evergreens. Thus it is well adapted to planting on the semi-arid plains and in dry, exposed situations. Under cultivation it is capable of rapid growth in diameter. A tree on the Agricultural College campus has averaged nearly one inch increase in diameter for each two years, the diameter when cut being seven inches at breast height, and with fifteen annual rings of growth. This rate of growth suggests this as a suitable pine for the tree plantation. When planted for lumber the trees may be planted twelve feet apart each way and the lower limbs be pruned off to form clean trunks as the trees grow in height.

This pine is quite easily grown from seeds, which are of good size, and which germinate readily.

(See directions for growing evergreens from seed).

The seedlings do not require shading when young as in the case of most evergreens. They should be transplanted when one or two years old to increase the number of fibrous roots. When four years old they may be set in permanent quarters if growth has been good.

LODGE POLE PINE, BLACK PINE.

(*Pinus Murrayana,* Oreg. Com.)

(Plate V. a. c.)

The lodge pole pine, so named from the use which the Indians once made of it in building their lodges, is a common evergreen in the hills and mountains of the northwestern states. It usually prefers northern slopes, which it covers with a dense growth. The trees are tall and straight and carry most of the foliage toward the top, especially when growing in forests. At a distance masses of this tree are noticeable on account of the yellow green of the foliage. It usually reaches higher altitudes than the rock pine. The needles are in bundles of two and are about two inches in length. The cones nearly equal the leaves in length and are composed of thick, hard scales, each of which is tipped with a slender prickle. The cones often remain closed and attached to the limbs sometimes for many years so that they occasionally become entirely overgrown by the enlarging stem.

A strong heat will cause the cones to open and allow the seeds to fall out. As the seeds may retain their vitality in the closed cones, sometimes for twenty years, a quick forest fire often brings about a reseeding of the burned district where this tree grew, by causing these old, "tight" cones to open.

The wood of the lodge pole pine is soft, light, and lacks durability. It is used to some extent for lumber, railway ties, mine timbers and fuel. The wood, when properly seasoned and treated with preservatives, is greatly improved in durability.

PLATE V.

a. c. Needles and cones of Lodge pole pine.
b. d. Needles and cone of Pinon pine.

PLATE VI.

a. c. Engelmann spruce tree and foliage.
b. e. Douglass fir tree and foliage.
d. Foliage of Blue spruce.

LIBRARY OF THE

PLATE VII.

Immature cone, foliage and trunk of Balsam fir (Abies lasiocarpa)

PLATE VIII.

Group of Colorado Blue spruce.
1. Branch showing scale-like leaves and berries of Rocky Mountain Red cedar (natural size).
2. Branch showing awl-shaped leaves and berries of low Juniper, (natural size).

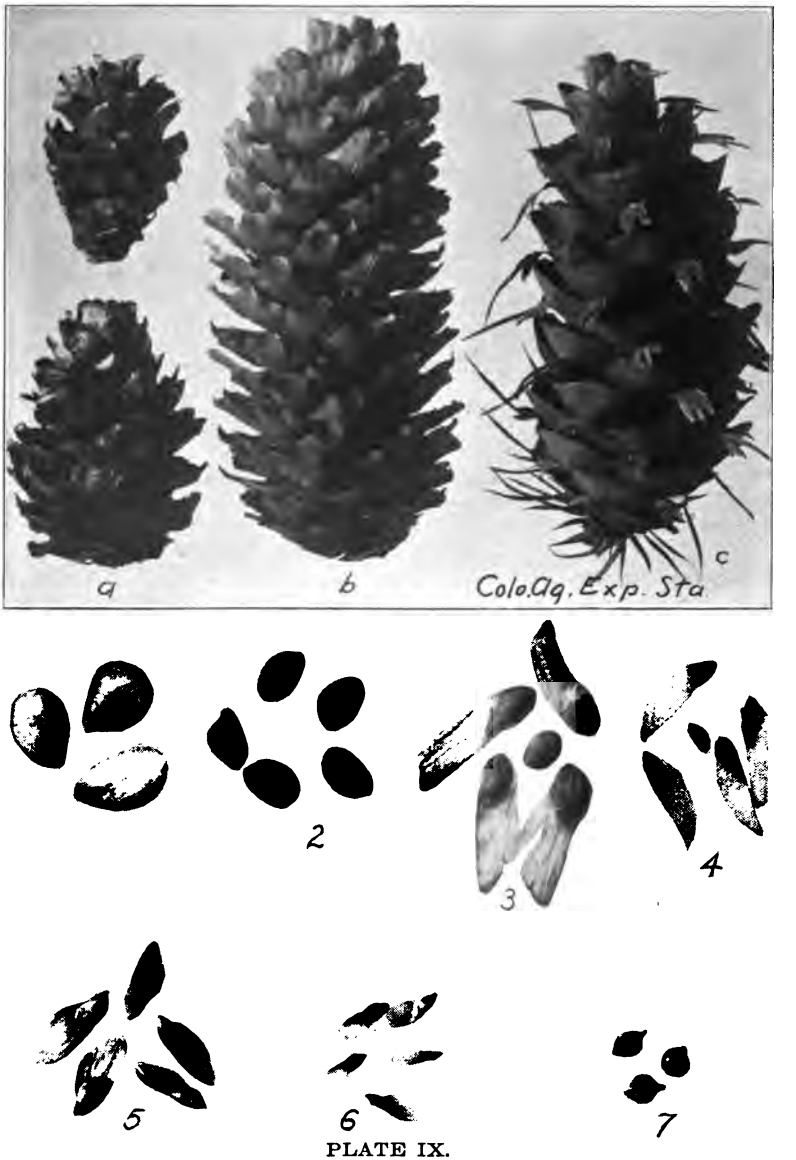


PLATE IX.

a. Cones of Engleman spruce.
b. Cone of Blue spruce.
c. Cone of Douglass fir.
1. Seeds of Pinon pine.
2. Seeds of Limber pine.
3. Seeds of Bull pine.
4. Seeds of Lodge Pole Pine.
5. Seeds of Douglass fir.
6. Seeds of Blue spruce.
7. Seeds of Red cedar.

(all natural size)

The lodge pole pine is capable of making a rapid growth under favorable conditions. It prefers a moist soil and may be used in the wind-break where such conditions prevail. When well established, however, it is hardy and enduring.

PINON, NUT PINE.

(*Pinus Edulis* (Engelm.) *Caryopitys Edulis* Colo. Bulletin 100.)

(Plate V. b. d.)

This is the pine from which the pinon nuts sold by fruit venders in cities are obtained. The tree is of small or medium size, with compact, pyramidal or rounded head. It occurs scattered or in open forests among the eastern and western foothills of Colorado, in southwestern Wyoming and western Texas and Arizona. It is not a tree of the high altitudes. The short, stiff leaves are in bundles of two and about one inch in length. The short, broad cones equal the leaves in length and are composed of few scales. The seeds are the largest of those of any other pine in this region. They are about the size of field beans and are wingless when separated from the scales of the cones.

This tree is useful mainly for its edible seeds, although the wood is sometimes made into lumber. It is quite extensively used for fuel and the manufacture of charcoal.

The pinon pine is adapted to growing in dry situations and for this reason may be planted where moisture is lacking. Its low, stocky growth adapts it for planting where a low mass of evergreen foliage is desired. The seeds germinate readily and this tree may be quite readily grown in this way. The seedlings may be transplanted at two years of age to encourage a compact root development.

GENUS *Picea*—THE SPRUCES.

The spruces are tall growing trees with conical or pyramidal form and tapering trunks. The needles are single, which distinguishes these trees from the pines, four angled and sharp tipped. At the base a short stalk-like portion is jointed to the green part of the needle and remains on the branchlet after the upper part of the needle has fallen. This makes the branchlets from which the leaves have fallen very rough and readily serves to distinguish the spruces from the firs.

The bark of the older limbs and trunks is usually dark grayish or reddish brown and consists of thin scales. The cones are hanging or pendulous when ripening and occur in the uppermost parts of the tree. They consist of thin scales each bearing two winged seeds. The seeds mature in the autumn of the first year. They are mostly small, pointed at the base and furnished with long, thin wings.

The spruces furnish some of our most ornamental evergreen trees, besides which they are useful in forming hedges, windbreaks and shelter belts.

KEY TO THE COLORADO SPECIES OF *Picea*.

A. Needles very stiff and sharp pointed, surface of twigs among the needles entirely glabrous or free from hairyness; cones 5-7.5 c. m. (2-3 in.) long.

1. Picea Parryana.

B. Needles less rigid and sharply pointed, surface of the twigs among the needles finely pubescent or hairy; cones about 4 c. m. (1⅝ in.) long.

2. Picea Engelmanni.

BLUE SPRUCE, COLORADO BLUE SPRUCE, SILVER SPRUCE.

(*Picea Parryana* (Andree) Sarg.)

(Plates VI. d., VIII., IX. b.)

This is one of the most admired and widely known evergreens and is certainly the handsomest of the spruces when well grown. It is somewhat limited in range, being found in Colorado and eastern Utah and northward into Wyoming. It commonly grows in small groups or groves along the streams in the mountain valleys and parks. It usually reaches a height of seventy-five to one hundred feet, occasionally taller, with a trunk one to two feet in diameter. The leaves vary in color from bright green to silvery greenish blue—the new growth being more distinctly bluish or silvery than the older foliage. Young trees are often very symmetrical and beautiful. When old the tree may become somewhat ragged and open and the color of the foliage may lose a degree of its blueness.

The bark is broken into rather small, oblong scales and on old trunks becomes thick and furrowed or grooved lengthwise. This character helps to distinguish the blue from the Engelmann spruce, the latter having the bark broken into rounded plate-like scales even on old trunks.

The cones consist of numerous thin scales narrowed toward the tips. They are usually prominent objects, as they hang in clusters in the upper part of the tree.

The wood is soft, light and weak and is sometimes used for lumber and fuel.

The blue spruce is largely planted for oranment and when well grown forms most beautiful specimen trees. For this purpose the bluest specimens are selected by the nurserymen, as the price which they bring is high in proportion to the blueness. This tree is well adapted to the formation of hedges and when well tended may be made impassible even to the smaller animals.

The blue spruce may be grown from seeds, gathered preferably from the bluest specimens, or native seedlings may be dug from the mountains where they occur. If wanted for specimen trees only the bluest should be saved, although the greener plants are equally useful for hedges and windbreaks. The finest specimens are usually obtainable through reliable nurserymen who grow them in large numbers, the best ones being propagated by grafting.

The blue spruce is at its best only when grown in a moist soil and under conditions of cultivation. When clothed in the new growth of the season such trees have the appearance of being frosted with pale blue, at which season they are unexcelled in beauty among trees.

THE ENGELMAN SPRUCE.

(*Picea Engelmanni* (Parry) Engelm.)

(Plates VI. a. c., IX. a.)

The Engelmann spruce is frequently confused with the blue spruce, which it often greatly resembles. It is a much larger tree than the blue spruce, in its northern range often growing to a height of 150 feet with a trunk four to five feet in diameter. Old trees are apt to be less regular in form than the blue spruce and the color is seldom so blue as the latter. The needles are less rigid and sharp than those of the blue spruce, so that an experienced nurseryman can usually distinguish the two by grasping the foliage with the bare hand. The leaves, furthermore, possess a disagreeable odor when bruised.

The surface of young twigs, under a hand lens, appears fuzzy or short hairy. This can be distinguished even by the naked eye if the twig is held up so that its outline is seen against the sky. The bark of large trunks is seldom grooved or furrowed as in the blue spruce, but is broken into rounded, plate-like scales of a reddish brown color.

The cones of the Engelmann spruce are seldom over one and a half inches long and the scales are often more rounded than those of the blue spruce.

The Engelmann spruce reaches the highest levels of tree growth and at timber line forms distorted spreading mats of scrubby growth. It is the most abundant of spruces in Colorado and forms extensive forests on the upper slopes and along the mountain streams. In its range it extends in general southward from the mountains of British Columbia through the interior mountain ranges of the continent to northern New Mexico and Arizona. It reaches its greatest beauty and size north of the United States boundary.

The bark is sometimes used for tanning leather. The wood is light and soft and is extensively manufactured into lumber, railway ties and to some extent is used for poles. It is probably our most valuable timber tree. The Engelmann spruce is not often planted for ornament, but is well adapted to such use in this state.

GENUS *Pseudotsuga*—DOUGLASS SPRUCE.

The members of this genus are tall, stately evergreens with much the same form as the spruces. They are nearly intermediate in some characters between the true spruces and the firs. The needles are single on the branchlets and are contracted at the base into a short stalk. They are soft, flattened, blunt at the tips and possess a prominent midrib in the form of a narrow ridge on the lower side. When the needles fall they leave small rounded scars on slightly raised portions of the branch. In these respects the Douglass spruces resemble the true firs. The cones, however, are in most respects like those of the spruces in that they are pendulous or hanging and that they remain entire when mature. The cones are readily recognized from those of the spruces, as well as other members of the pine family, by their feathered appearance, due to the presence of slender-toothed bracts that project from between the scales. This character is so prominent that these trees can be recognized as far as the details of the cones are visible.

Only two species in this genus are known in North America, one of which occurs in Colorado.

DOUGLASS SPRUCE, DOUGLASS FIR, RED FIR.

(*Pseudotsuga mucronata* (Raf.) Sudw.)

(Plates VI. b. e., IX. c., 5.)

The Douglass spruce is known by a number of common names throughout its range. It occurs among the hills and mountains of the greater portion of the Northwest, extending from British Columbia and Alberta on the north to northern Mexico and Texas on the south. It is a tree of conical form when young. It reaches its greatest size in the moist climate near the coast of Washington and Oregon and in the western foothills of the Cascade mountains, where it reaches a height of 200 feet or more with a trunk sometimes 10 to 12 feet in diameter. In the drier inland regions it is usually less

than one hundred feet tall and two or three feet through. The bark remains comparatively thin and smooth for a number of years, but on old trunks becomes thick and deeply cracked and furrowed into gray, coarsely broken ridges. The wood is light red or yellowish in color and variable in density and quality. It is largely manufactured into lumber in its northwestern range, and is extensively employed in construction work, railway ties, piles, and for fuel. Two varieties of this tree, the red and the yellow fir, are distinguished by lumbermen. The former of these is coarse grained and dark colored and is not considered so valuable as the latter. The bark is occasionally used in tanning.

The Douglass spruce is planted quite extensively as an ornamental tree in the eastern United States, and numerous forms or varieties are in cultivation. It is a tree of rapid growth, especially when planted in a moist soil. It has not made as healthy a growth on the Agricultural College grounds at this station as the blue spruce. It is readily grown from seeds, which are of fair size. This evergreen may be recommended for planting in the windbreak and for specimen trees on the lawn.

GENUS *Abies*—THE FIRS, BALSAMS.

The firs are tall growing, conical trees quite similar in appearance to the spruces. They are fond of the higher altitudes where the cold air and the moisture of frequent storms bring them to their greatest perfection. The leaves, like those of the spruces, are simple and grow from all sides of the branchlets. Those on the lower sides of the twigs, however, turn upward in such a way as to form flattened masses of foliage. The branches arise in whorls from the sides of the main trunk so that when viewed from the side such trees appear in the form of circular terraces of foliage disposed with beautiful regularity.

The needles are flattened, usually grooved above and slightly notched at the tip. The cones occur only in the topmost parts of the trees and stand erect on the upper side of the branches. They are mostly purplish or blackish in color, with thin, closely crowded scales. When mature the cones break up by the falling away of the scales, so that complete cones of the firs are never found beneath the tree.

The bark on young trees is smooth, but becomes roughened and broken on old trunks. The wood is mostly soft and brittle and is not prized by the lumbermen.

The name Balsam, which is often applied to the trees of this genus, is suggested by the presence of balsam or resin vesicles in the bark.

The balsam fir of the northeastern states and Canada *(Abies balsamea)* possesses balsam-containing blisters in the bark from which the substance known in commerce as "Canada Balsam" is obtained.

KEY TO THE COLORADO SPECIES OF *Abies*.

A. Leaves of vigorous lower branches 2.5-4.5 c. m. (1-1¾ in.) long; the two resin tubes, as seen in cross section under hand lens, deeply imbedded within the leaf tissue. Cones purple or nearly black.

1. Abies lasiocarpa.

B. Leaves of vigorous lower branches 4.5-7.5 c. m. (1¾-3 in.) long. The two resin tubes close to the lower surface. Cones green, yellow or purple.

2. Abies concolor.

BALSAM FIR, ALPINE FIR.

(*Abies lasiocarpa.* Nutt.)

(Plate VII.)

This tree is distributed throughout the mountainous parts of western North America. In Colorado it frequents the high mountain slopes and summits. It is a medium sized tree seldom over 100 feet tall, in this state, and two feet in diameter.

The leaves on the cone-bearing branches are usually short, stiff, and curved upward and tipped with sharp points. The cones are frequently almost black in color and are usually smeared with pitch. The bark on young trunks is quite smooth with numerous transverse scars, but on old trunks becomes cracked and scaly.

The wood of this tree is considered of little value by the lumbermen, as it lacks strength and durability and is adapted only for the coarsest quality of lumber. It is used for fuel to some extent. The writer found, in the cutting of timber from one forest reserve, that this fir was being removed to make room for the more valuable Engelmann spruce with which it was growing. This fir is planted to some extent as an ornamental tree in the northern United States and Europe.

WHITE FIR.

(*Abies concolor,* Lindl.)

The white fir, with its regular whorls of frond-like foliage masses, is a very handsome tree. During the first year or two the leaves are similar in color to those of a good specimen of the silver spruce, which it often rivals in beauty. It is a much larger tree when fully grown than the preceding species. It is the only fir within the arid regions of the Great Basin and of southern New Mexico and Arizona. In Colorado the white fir is found only in the southern half of the state extending to the Pike's Peak region. Some handsome specimens of moderate size are to be seen in North Cheyenne Canon, near Colorado Springs. The leaves are considerably longer than those of the balsam fir and the cones are larger and usually lighter in color. The wood, while coarse grained and not strong nor durable, is sometimes used for lumber of which packing cases are made. The tree is planted to some extent for ornament and is worthy a trial, as well grown specimens are pleasing in form and color and may serve to introduce variety in the evergreen plantings in parks and about the house.

Juniperaceae—JUNIPER FAMILY.

The members of the juniper family are distinguished from those of the pine family principally by the fruit. Thus, instead of forming a dry cone composed of woody or parchment-like scales, the junipers possess a berry-like fruit, in the pulp of which the seeds are imbedded. These berries, however, were at first much like the very young cones of the pine family. The scales of which they are composed are enlarged at the outer end and are comparatively few in number. After the ovules are fertilized by pollen from the staminate flowers, which in the junipers occur on distinct trees, the scales grow together and form the so-called juniper

berry. On close examination, marks indicating where the scales were located can be easily seen.

The seeds of the junipers are furnished with hard, bony coatings which enable them to pass unharmed through the alimentary canal of birds, which sometimes feed upon them, and in this way distribute them to new locations.

The junipers are strongly aromatic and from some species volatile oils are obtained which are used in medicine and in the manufacture of perfumes.

The wood of the juniper is close grained, not hard, but durable. Most of the species of junipers which occur in this state are low, spreading, shrubby plants which are not adapted to the production of lumber. These low-growing sorts, however, are well suited for planting in the shrubbery border, on exposed banks and to cover the tops of walled terraces and rockwork.

Two genera of the juniper family are represented in Colorado, but only three species commonly reach the stature of small trees.

KEY TO THE COLORADO GENERA OF THE JUNIPER FAMILY.

A. Leaves in whorls of three, on mature branches, awl-shaped, spreading, 10-12 m m. (⅜-½ in.) long, channelled and whitened above, convex and green below. Buds scaly.

Genus Juniperus.

B. Leaves opposite in pairs, on mature branches, scale-like and flattened against the branchlets to which they are usually grown fast; about 2-3 m m. (⅛ in.) long. On young trees and vigorous shoots the leaves are usually longer, slenderly pointed and somewhat spreading. Buds naked.

Genus Sabina.

GENUS *Juniperus*—THE JUNIPERS.

(Plate VIII. 2.)

The species of junipers which occur in Colorado frequent the rocky hills and exposed mountain slopes. They are distinguished from the red cedars or savins principally by the leaves being comparatively long and joined to the branch much like those of the spruces. The berry-like fruit of the junipers is borne close against the side of the branch, while that of the red cedar is on the end of a very short branch.

Two species of the genus are known in this state. The first of these, the mountain or low juniper *(Juniperus sibirica)* (Plate VIII. 2) is a low spreading shrub common in the foothills and rocky places in the mountains. Its leaves are abruptly bent at the base and are deeply grooved on the upper surface.

This shrub is worthy a place in the shrubbery border and from

its hardy, drought-resisting character may be used where moisture is not plentiful

The common juniper *(Juniperus communis)* sometimes reaches a considerable size, especially in its eastern range. In its low form it is scarcely distinguishable from the former species, but is apt to be more erect and with straight, nearly flat leaves with tapering points.

The distilled liquor commonly known as gin owes its flavor to the use of juniper berries in its manufacture.

The common juniper is adapted to forming low hedges, as it endures clipping well.

GENUS *Sabina*—RED CEDARS, SAVINS, JUNIPERS.

(Plate VIII. 1.)

The common red cedar is the type of tree of the present genus. The foliage consists usually of two somewhat distinct forms of leaves. Those on the main branchlets are frequently one-fourth to three-eighths inches long on vigorously growing trees, with the pointed tips free and somewhat spreading. On the smaller lateral branchlets the leaves are usually less than one-eighth inch in length, are scale-shaped and broadly pointed. Both forms of leaves adhere closely to the branchlets on which they grow so that the younger stems are entirely covered by the leaves. After one or two years the longer leaves die and turn brown, but do not entirely disappear until the branch is several years older.

The oldest leaves are shed in spring of each year at the beginning of the growing season, but instead of falling singly as in the junipers, the small lateral branchlets drop off, carrying with them the closely adhering scale-leaves.

The heart wood of the red cedars is soft but fine grained and very durable and possesses a pleasing fragrance which is retained almost indefinitely. The wood has been extensively employed in the manufacture of water pails and wooden ware, for interior finish and for cabinets and chests for protecting furs and woolens against the ravages of moths. It is the principal wood used in the manufacture of lead pencils and is probably the only wood sold by the pound. The rapidly diminishing supply for this purpose is being felt by the manufacturers of pencils, who are beginning to consider possible substitutes.

The oil of red cedar, distilled from the leaves and wood, is used to some extent as a perfume, as it imparts the characteristic odor of the wood to cheaper woods.

The berries ripen in the autumn of the season they were produced.

Of the four species of red cedars known in Colorado three are sometimes trees of small or medium size. The characters which separate them are not easily recognized except by botanists.

The Utah red cedar (Sabina utahensis) is a bushy tree seldom more than twenty feet high, which occurs in the desert region between the Rocky and Sierra Nevada Mountains. It is found in the western parts of this state on dry mountain slopes and tablelands. It is locally used for fuel and fencing and the fruit, which is a rather dry, sweet berry, is used for food by the Indians, either fresh or ground and baked into cakes.

The single-seeded red cedar (Sabina monosperma) occasionally reaches a stature of forty to fifty feet in favorable locations. It occurs along the eastern base of the Rocky Mountains in the southern half of Colorado and extends to western Texas, over the mountain ranges of Nevada and into Mexico. It is often associated in southern Colorado and Utah with the pinon pine.

It is usually an irregular, open-headed tree, with red-brown bark on the naked branchlets and thin, grayish, scaly or shreddy bark on the trunks. The fruit is about one-eighth to one-fourth inch long, black with a whitish bloom and contains usually one or rarely two or three grooved seeds. The wood and fruit of this species are used for the same purposes as in the preceding species.

The Rocky Mountain Red Cedar (Sabina scopulorum) (Plate VIII 1.) is widely distributed throughout the northwestern portions of the United States, from the eastern foothills of the Rocky Mountains to the coast of British Columbia and Washington, and from Alberta to western Texas and northern Arizona. It frequents the foothills and river bluffs and is our common red cedar in most parts of Colorado. It reaches a height of thirty to forty feet, when favorably situated, and forms an irregular round topped head.

The berries are bluish black with a bloom and contain one or two bony-shelled, grooved seeds. The fruit is usually somewhat larger than that of the preceding species and ripens at the end of the second season.

The red cedars, on account of their very fine foliage and branchlets, may be effectively used among other evergreens to give variety to the planting. Their foliage is usually somewhat grayish in winter. Although of slow growth their hardiness and the fact that they bear pruning well fits the red cedars for use in forming hedges and windbreaks.

Bulletin 131 July, 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Arsenical Poisoning of Fruit Trees

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915
GOVERNOR HENRY A. BUCHTEL, } *Ex-Officio.*		
PRESIDENT BARTON O. AYLESWORTH, }		

A. M. HAWLEY, SECRETARY — CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*,	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.,	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
W. H. OLIN, M. S.,	AGRONOMIST
W. G. SACKETT, B. S.,	BACTERIOLOGIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOUGLASS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S.,	ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S.,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS
MIRIAM A. PALMER,	ARTIST
L. C. BRAGG,	ASS'T IN ENTOMOLOGY

STATE FRUIT INVESTIGATIONS

O. B. WHIPPLE, B. S., GRAND JUNCTION,	FIELD HORTICULTURIST
GEORGE P. WELDON, B. S., DELTA	FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

ARSENICAL POISONING OF FRUIT TREES.

WM. P. HEADDEN.

I was called upon at one time to investigate the cause of the death of some shade and ornamental trees, and the bad condition of the property in general. The claim was advanced that arsenic and lead were the cause, more particularly the former. The assertion was made that animals had died as the result of feeding upon the grass growing on the premises. Examination of the grass, the bark of the trees, the soil, and the dust which had collected in unused portions of the buildings, all showed an abundance of arsenic, lead and copper.

In connection with the preceding facts, the probable cause of the death of the trees seemed apparent and yet certain considerations led me to be cautious in insisting upon the arsenic present as the cause. For instance, calcic arsenite was at that time being used on our fruit trees to destroy the codling moth—the whole tree from the outermost twigs to the very base of the trunk was, I well knew, literally bathed with this arsenical preparation several times in the course of a season. The whole of this arsenic sooner or later found its way to the soil. I had not, at that time, proved by direct experiment, nor learned that any one claimed that the fruit trees had been injured by this arsenic. This seemed to me so strong an argument against the too ready assumption that arsenic was really the cause of the death of the trees, that I felt obligated to caution the attorneys that it was not clear to my mind, that neglect had not contributed more to the condition of the property than the causes complained of. Still the facts were well established, i. e., the trees were dead and arsenic was present, also lead and copper, and in spite of the fact that our apple and pear trees were being sprayed, a number of times annually with arsenical preparations and no injury reported, except in cases where the arsenic had been applied in a soluble form, I was quite fully convinced, that the arsenic had contributed largely to the death of the vegetation on this property.

The protection against arsenical poisoning in the case of our orchard trees is the insolubility of the arsenical preparations used in spraying and further that these preparations shall not be changed or become soluble in the soil. In the case referred to, it would have been judged that the iron and especially the lime present, both as carbonate and sulfate, was sufficient not only to render the arsenic insoluble but also to prevent its being brought into solution again, still it was my opinion that the arsenic was really the principal cause in the destruction of the vegetation in question.

While the conditions met with in the case of this property were not identical with those obtaining in orchard culture, they had enough in common with them to convince me that there were but two conclusions to draw, either that I was in error in regard to the agency of the arsenic in this case, or that there would come a time, and that soon, when the arsenic applied would eventually find its way into the soil, and prove a source of danger to the trees. I was, at that time, going on four years ago, so fully convinced that the arsenic would become a source of grave danger, that I ventured to express this veiw to the orchardists of the State and cautioned them that the probability of injury from this cause was imminent.

Prof. Gillette, who, as an Entomologist, is interested in the control of insects injurious to the fruit crops of the State, has repeatedly suggested that I should take up this line of investigation, Prof. Paddock, also, who, as a Horticulturist, is interested in the diseases of the trees—has made the same suggestion. These statements are not made to devolve any responsibility upon these profes sors but to show that this view has not been hidden from the people or my colleagues and the presentation of this bulletin is not a hasty resolve or a thing done without a very keen appreciation of its importance not only to the orchardists of Colorado but to all orchardists.

I will add before leaving these introductory paragraphs, that this work in my Department is directly an outgrowth of my attempts to study the alkalies of this State, but I deem it both just to the interests of the State and wise to segregate it, and present it at the earliest advisable time, irrespective of the rest of the work.

It will appear in the proper place how the injuries herein described and explained are influenced by the alkali, indeed, the orchardists themselves have repeatedly suggested this by such questions as: Has our strongly alkali water any effect on our spray material, specifically upon the lead arsenate?

While the suggestions of danger were made so long as three years ago, no observations of any trouble were officially made public until January 1907, when Mr. O. B. Whipple in his report as Field Horticulturist of the Western Slope Fruit Investigation, calls attention to certain difficulties under the title of Root Rots. I give the whole of his report touching upon this subject taken from Bulletin 118 of this Station:

ROOT ROTS.

"Two apparently distinct forms of root rot are found. One form, which is proving the least destructive of the two, seems to show no preference for varieties, and confines itself to that part of the tree below the ground. The other seems to work exclusively on the Ben Davis and Gano, and the trunk as well as the roots are affected. The disease often extends upward into the large branches. The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out

in sharp contrast to the healthy tissue. The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. Two seasons are required for the disease to kill the trees. The first season the trunk is girdled and the foliage drops early. This early ripening of the foliage is often the most prominent symptom and diseased trees can be easily picked out in the early fall. (See Plate I., lower figure). Trees showing an early bronzing of the foliage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit, and dies in mid-summer, the fruit and leaves clinging. (See Plate I., upper figure). The disease seems to be infectious, as the trees appear in groups, and in many cases it appears as though it were carried by water. When a diseased tree is found, several more are generally found in the same row. However, other varieties besides the Ben Davis and Gano may stand in the same row with diseased trees on either side and show no sign of contracting the disease. The fact that Ben Davis and Gano are very tender as regards the application of arsenical sprays has suggested to my mind that the trouble may be due to arsenic collecting about the crown of the tree and killing the bark. However, the fact that trees sprayed with arsenate of lead and arsenite of lime are alike affected, seems to be contrary to such a hypothesis.

"Prompt removal of the trees affected seems at present to be the only treatment that can be suggested. Reports indicate that the disease has only been in the orchards two or three years at the most. Soil conditions seem to have no relation to the disease, as it is found on all kinds of soils."

The description of the affected trees as given by Mr. Whipple is, I believe, entirely reliable as he has been in this field for several years, and has had opportunity to observe these trees at all stages of the affection. I can, in fact, corroborate his statements as Mr. Whipple was kind enough last Autumn and again this spring to point out a number of these trees at different stages in the process of dying. While the appearance of brown spots on the trunk of the tree are observable early in the progress of this trouble, they are not the seat of the trouble, which beginning on the crown of the tree has by this time advanced to the trunk. Whether it ever begins on the roots below the crown is not at present known. It is not to be wondered at that Mr. Whipple, without a definite knowledge of the cause of the trouble, states that the disease seems to be infectious. He pointed out to me a row of Ben Davis trees, four of which were already dead, with leaves and fruit still clinging to them. In the adjoining row was another tree which was likewise dying, as I now recall it—this tree stood at a point where the irrrigation water crossed from the row of four dead Ben Davis trees and passed close to this one, seemingly justifying Mr. Whipple's inference that the disease is infectious and also the further statement, "and in many cases it appears as though it were carried by water." My explanation of this is a different one as will appear in a future paragraph.

Mr. Whipple in the next sentence, calls attention to an important fact, i. e.—that the two varieties, Ben Davis and Gano, are very sensitive to arsenical sprays, and suggests the possibility that the trouble may be due to arsenical poisoning, but seems to dismiss this as an untenable hypothesis. Another point in Mr.

Whipple's very brief account of this disease is that the disease had been noticed for only two or three years. Information which he and I have since gathered corroborates this statement; the earliest observation of the affection of the trees of which we were able to learn was in 1904 and trees have been dying in certain orchards annually since that date.

VARIETIES AFFECTED.

The varieties affected in this way are by no means confined to the Ben Davis and Gano. The following varieties are also affected: Spitzenberg, Early Harvest, Wolf River, Lawver, Blacktwig, Baldwin, Jonathan, Grimes Golden, and Pewaukee, and without doubt, other varieties might be added if search were made to find every variety affected in this way. The trouble also extends to pear trees, but I have studied apple trees mostly.

AREA INVOLVED.

At this writing I am not prepared to give any territorial limits to the trouble. I have observed it from near Fruita almost to Palisade and in the neighborhood of Delta. I am further credibly informed that the same condition of the trees has been met with in the neighborhood of Canon City. If this latter statement is correct, our principal orchard growing sections are involved and the importance of definitely establishing the cause and if possible, a correction for the trouble, becomes very great.

THE NUMBER OF TREES AFFECTED.

This would be very difficult to determine and I have no data on which to base even a rough estimate, but an idea may be obtained from the following facts. One man stated that in the last few years, he had lost 50 per cent of his Ben Davis. Another stated that he began pulling up a few trees four years ago and this year he had removed nine trees and there were others which he should have removed; another man had removed twelve and still another the same number. The four Ben Davis trees in the row that I saw last October, together with others had been removed this Spring and there were still other trees in this orchard which were affected. I visited one orchard in which there was a large number of affected trees—in other orchards, there are only a few. The total number of affected trees in the orchards of the Western Slope, is already unfortunately large.

THE PROBABLE CAUSE OF THE TROUBLE.

I have already clearly indicated my conviction that the cause of the trouble is arsenical poisoning; that there are some trees suffering from other causes is quite certain but the cause of the greater

portion of the trouble is the arsenic which has accumulated in the soil. The expression of this conviction is not a hasty one, for I am fully alive to how much it means to this state and all other orchard growing states where similar soil conditions prevail, but it is for the best interests of orchardists that they should know the facts pertaining to the death of their trees and the conditions of their soil.

THE ACCUMULATION OF ARSENIC IN THE SOIL.

The spray material used in combating the codling moth is either a calcic arsenite or lead arsenate. The number of sprayings applied vary from two or three to nine during the season. I do not think that this Station has ever recommended more than three sprayings during the season, but many orchardists apply more. The amount of lead arsenate used is from four to six pounds to each 100 gallons of water. The average orchardist does not consider the amount of arsenic thus applied to a single tree a very large quantity, and he cannot be expected to consider the nature and possibilities of the material that he is applying, so in many cases he applies, as he thinks, wisely, a liberal quantity, sometimes using eight to ten pounds of lead arsenate to 100 gallons of water, and applies eight or ten gallons of the turbid liquid to the tree. If six pounds of pasty lead arsenate be used to 100 gallons of water and ten gallons of the mixture be applied to a tree we have six-tenths of a pound of the pasty arsenate, or in round numbers, three-tenths of a pound of dry lead arsenate.

Practically the whole of this eventually finds its way into the soil. If this be repeated three times during a season we have 1.8 pounds of pasty lead arsenate or 0.9 pounds of dry arsenate applied to each tree, or considering that the dry lead arsenate contains 25 per cent of arsenic acid, we have 0.225 pound of this substance per tree and allowing 80 trees to the acre, we have 18 pounds of arsenic acid to each acre of the orchard. If this amount of arsenic acid were evenly distributed through the first foot of soil, it would correspond to four and a half pounds of arsenic acid for each million pounds of soil, or 4 1-2 parts per million. This arsenic is, however, not evenly, but very unevenly distributed, as the spray mixture runs down the trunk of the tree and accumulates in the soil at its base. It is not done one year only, but every year, unless there should be no fruit. Some of our orchards have already been sprayed for eight or ten years and a few of them for even a longer period, so that we would expect to find a considerable accumulation of arsenic in the soil, especially in the soil at the base of the trees. This corresponds to the facts as found by analysis. In one sample taken beneath the head of a twelve-year-old apple tree, and representing the soil to the depth of five inches, I found arsenic corresponding to 30.6 parts of arsenic acid to each million parts of the soil; in

another, soil 25.5 parts; in another 26.0 parts; in another 38.2 and in still another, 61.3 parts per million. The sample giving 38.2 parts arsenic acid per million was taken at the base of the tree and to a depth of one foot, the last sample, giving 61.3 parts arsenic acid per million, was taken at the base of the tree and to the depth of four inches. All of the samples were taken either in the Spring of the year or at least some time after the last spraying, so that they ought to fairly represent the orchard soils. We find in fact, what was from the beginning patent, namely that the arsenic does accumulate and is already present in our orchards in dangerous quantities, if it, by any means, should become soluble.

THE ARSENIC IS TAKEN UP BY THE TREES.

It is altogether correct that the spray material applied is a compound of arsenic either difficulty soluble or insoluble in water as calcic arsenite or lead arsenate. It is also true that literally hundreds of trees have already died or are sick, as I believe, beyond hope of recovery. The symptoms are the same. The duration of the tree after showing the first early ripening of its foilage is about one year; the attack of the disease is at the same point, and progresses in a uniform manner. Mr. Whipple describes its course as follows:

"The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out in sharp contrast to the healthy tissue."

"The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. (Plate II., Fig. 1). Two seasons are required for the disease to kill the trees. The first season the trunk is girdled and the foilage drops early. This early ripening of the foilage is often the most prominent symptom and diseased trees can be easily picked out in the early fall. Trees showing and early bronzing of foilage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit and dies in mid-summer, the fruit and leaves clinging."

I have seen no tree in which the trouble has advanced to that stage indicating its death during the following summer, but that some of the roots, in fact, most of them in nearly every case, had been attacked, the bark destroyed to a greater or less extent, the woody tissue stained brown and the bark at the base of the trunk severely attacked just below the ground. It is from this point that the trouble seems to take its start. Some facts, however, particularly the condition of some of the roots, they being entirely dead, while others standing in just as close a connection with the diseased crown are in much better condition, suggest that the attack may not be confined to the crown. The condition of the crown produced by this trouble is shown in Plate II., Fig. 2, also the stained or discolored condition of the tissue. This is a photograph of a stump of a Ben Davis tree which was removed this spring, and would have died this summer. Plate III., Fig. 3 is that of another Ben Davis tree

from another orchard and shows how the woody tissue is stained. The notch shows where a portion of the stump was removed for the purpose of examination. This tree was in bloom when dug up. It was perfectly representative of a number of other trees in the same orchard which had already been dug up or had been marked for removal. Many trees in this immediate neighborhood are affected in the same manner. The trouble is not confined to one orchard. In this case we found it in four, we might say, contiguous orchards. I have taken portions of at least 14 different trees. They were from a considerable variety of soils and were trees that had just been removed or which we removed ourselves, or are still standing in the respective orchards. So far as I could learn, only two of these trees failed to show some life this season and one of these was a pear tree which we dug up ourselves. This tree had been cut back severely in 1907 and had thrown out a few shoots, some of which had made a fair growth. None of them were trees which had died and remained standing and had had an opportunity to absorb arsenic as dead trees. As stated, some of the trees represented by our collection are still standing and were in full bloom at the time we removed the roots and branches. The condition of the roots and bark, however, was that produced by the long continued action of the poison.

The conditions found are as follows: The bark at the base of the trunk and just beneath the ground is destroyed and the damage extends up the trunk sometimes even into the limbs. (see plate II.) This damage is shown on the trunk by the bark being brown and sunken. On the roots, the bark is disintregated as is well shown by Plate IV., Fig 1, a sample taken and photographed by Mr. Whipple. Often, in the advanced stages of the trouble, the bark is almost charred and the wood itself is even blackened. The tissue is strongly attacked and yields to the rasp like wood charred sufficiently to destroy its fibre. It looks and acts like wood acted on by a dilute acid, sulfuric acid for instance, only the darkening is not, as a rule, so intense as would correspond to the same degree of disintegration by this acid.

The limbs and branches of trees affected in this way usually, but not invariably, present a case of "black heart." The interior portion of the branch is strongly discolored with a margin pronouncedly darker than the rest of the interior. (Plate IV., Fig. 2; also Plate III., Figs. 1 and 2). This condition is usually attributed to another cause, freezing at some time or other, but we have pretty direct proof that in these cases, it probably has been caused by the poisoning of the tree. It is a rule that branches of healthy trees show this difference to a very small extent, they being usually white from the center to the circumference. Even in Fort Collins, where we have severe changes in the temperature,

this seems to be the case. A branch from a neglected tree in my garden is white throughout (Plate IV., Fig. 4). The age of this tree is not less than 15 years, and has to my knowledge been subjected to temperatures ranging as low as -40 degrees F., and often below -18 degrees F. I do not know the early history of this tree, and do not wish to give more weight to the fact mentioned than is due. I have not examined pear trees as carefully as I have apple trees, but the few branches that I have observed were not discolored in this manner. Plate IV., Fig. 3 represents a section of the trunk of a pear tree, killed by arsenic, and shows the manner in which the wood is stained.

Another effect of this trouble is to cause the bark to split and the wound to bleed. (Plate V., Figs. 1 and 2). This result may be partly and possibly wholly induced by another cause. Mr. Whipple suggests that the splitting open of the bark may result from the girdling, but this will certainly not apply in many cases, though it may in some. I have in mind two orchards in which this cracking and bleeding occurs to such an extent that any person whether he were accustomed to orcharding or not would take notice of it. One of these orchards is today rated as a very fine one.

With these general statements concerning the manifestations of the difficulty, I will give the facts on which the statement rests, that the arsenic is not only in the soil but has been absorbed by the trees.

I have taken samples from fourteen trees, eleven apple and three pear trees. These samples consist of roots, stumps, one trunk and branches. I should add to the above two samples of the deposit formed by the bleeding referred to in a preceding paragraph. On these various samples, thirty tests for arsenic were made and its presence was established in every instance. I did not attempt to make quantitative determinations except in a few cases which showed from 1.25 parts to 12.77 parts of arsenic per million of the woody tissue. I found the reaction for arsenic stronger in the roots and crown of the trees than in the branches, but could not with certainty distinguish any difference in the amount of arsenic present in the green or natural colored portion of the limb and the discolored portion.

I do not wish to weary the general reader with technical details, but it is proper that he be assured that the arsenic reported as having been found in these thirty different samples, was not contained in any or all of the reagents used. The proof of this was obtained by using a piece of oak wood and carrying it through as though it were a sample of an apple tree when a negative result was obtained showing that both the wood and the reagents were free from arsenic. This was not the only precaution, for four blank tests were made during the work to make sure that no error should arise from

this source. The care taken was in all ways as circumspect, so far as the analytical work was concerned, as though the examination of human viscera were in my hands. Another source of error lay in the danger of getting some particles of spray material with the bark of the sample. This was obviated by removing the bark from both the roots and branches, before taking the sample for analysis.

In one case, that of a pear tree, the bark was examined; in this case the bark was smooth and sound enough to permit of its being washed with a stiff brush. It gave a fainter reaction for arsenic than the wood which it covered.

With these statements it may fully suffice if I give the details of only two samples a little more fully.

One taken from the trunk of a small pear tree ten years old. Section cut out 30 inches above the ground, bark entirely removed, wood quite generally stained but not deeply so like the roots or central portion of many of the branches of the apple trees. This section is shown in Plate IV., Fig. 3. The wood is hard but rasps easily. I took 60 grams, almost exactly two ounces, destroyed the wood by means of sulfuric and nitric acid; collected the arsenic as arsenate of Iron; dissolved in sulfuric acid and introduced it with proper precautions into an active Marsh apparatus and obtained arsenic corresponding to 2.55 parts of arsenic acid per million. Owing to unavoidable losses, the arsenic obtained is too low.

The second one is a sample of a stump. I cleaned it thoroughly by paring off all bark and soiled portions and rasping it. I took two ounces as before, proceeded in exactly the same manner and obtained arsenic corresponding to 12.77 parts of arsenic acid per million. Every sample was proceeded with in just as careful a manner as these two, and arsenic was easily proven to be present in the tissue of every sample, whether it was taken from the central, the intermediate or exterior portion of the root or limb.

We have seen that the arsenic is accumulating in the soil, having already reached as large an amount as 61.33 parts of arsenic acid in a million of soil.

I have stated in Mr. Whipple's words, the manner in which the trees are affected and have given the description of what I myself found.

Further we have shown that in these dying trees arsenic is present in the roots, the trunk and branches varying up to 12.77 parts per million.

ARSENIC IS THE CAUSE OF DEATH.

So far the question, Is the arsenic really the cause of the corrosion of the bark beneath the ground, the killing of the bark on the trunk, the killing of the roots and the staining of the wood, in short is it the cause of death? has not been answered. I have stated

Colo. Ag. Expt. Sta.

PLATE 1.

Colo. Ag. Expt. Sta.

PLATE 2

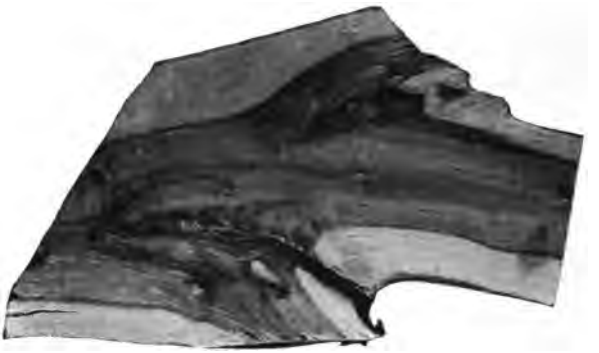


Fig. 2

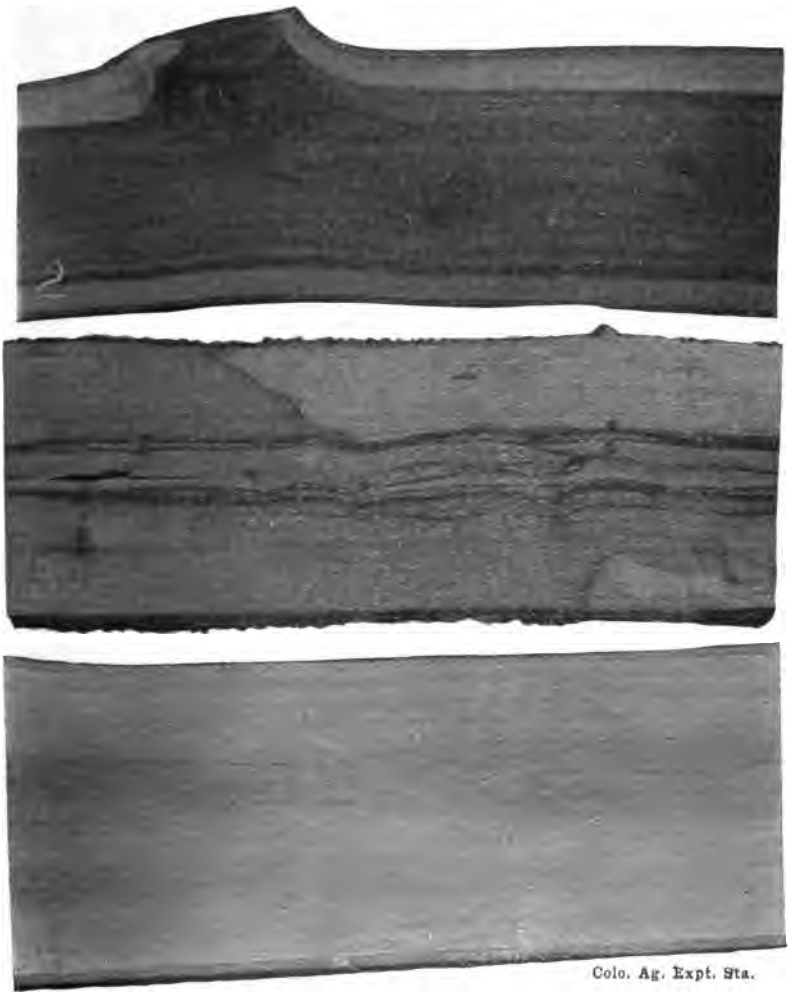
Colo. Ag. Expt. Sta.

Fig. 3

Fig. 1

PLATE 3.

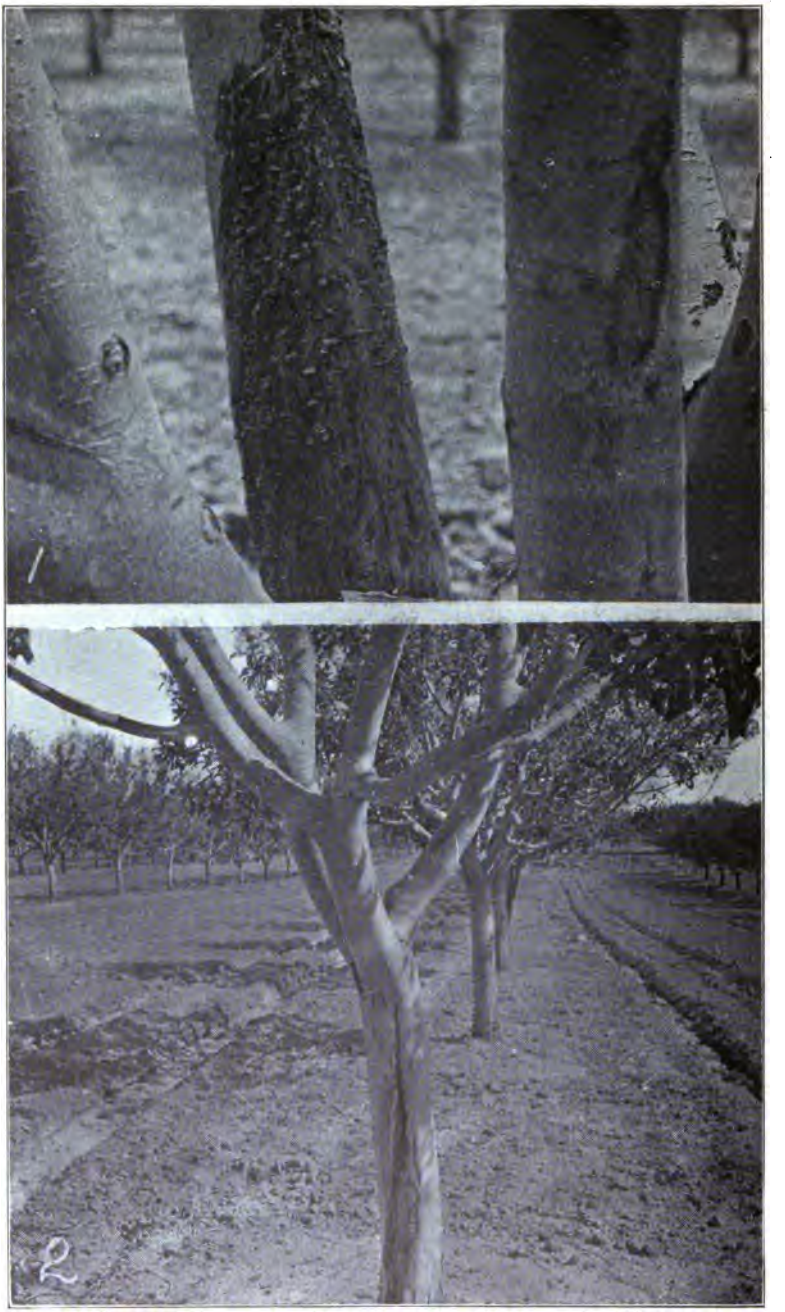
Fig. 1



Colo. Ag. Expt. Sta.

PLATE 4.

LIBRARY OF THE UNIVERSITY



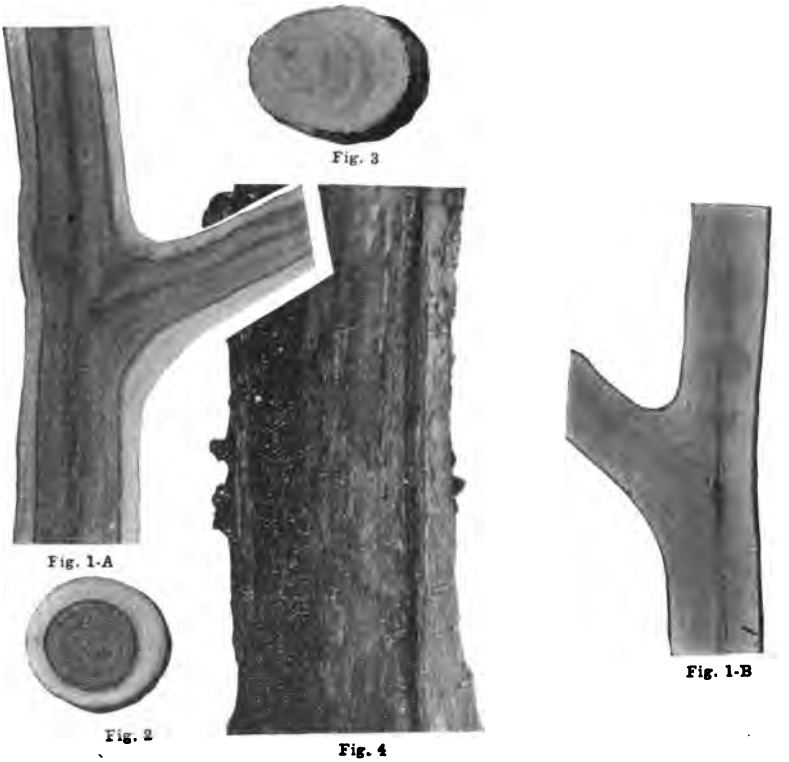
Colo. Ag. Expt. Sta.

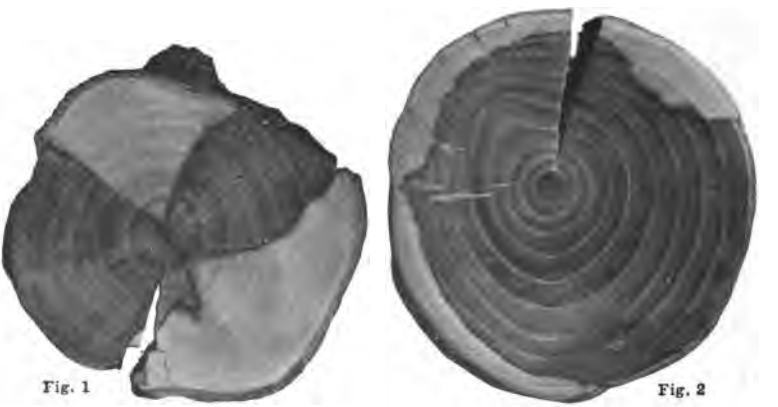
PLATE 5.

Colo. Ag. Expt. Sta.

PLATE 6.

LIBRARY OF THE UNIVERSITY





Colo. Ag. Expt. Sta.

PLATE 7.

my conviction that many trees have been killed by arsenic and that others are hopelessly sick. I will give some reasons for my belief. First, it is a well-known fact that soluble arsenical compounds will kill plants. It has been found that Herbicide, a preparation found on the market, is essentially a solution of an arsenical compound. Both white arsenic and arsenic acid have been shown by various experimenters to be deleterious even when present in very small quantities, one part per million in solution. Second, I took some greenhouse plants, coleuses, daisies and geraniums in two and a quarter and three inch pots and added from 0.05 to 0.5 grams, approximately from 3-4 of a grain to 7.5 grains, of sodic arsenite and the smallest amount used sufficed to kill the plants. Third, I know of two trees, one killed outright, at least this is the testimony of the owner, there is nothing but the stump left at the present time, and the other partially killed. It was my good fortune to see this tree in October last when the affected limb was still on the tree with the dead and blackened leaves clinging to it. Inquiry elicited the statement that it had been killed by arsenic as the other tree had. In the case of the tree that had died and been removed, they had made arsenite of lime under it or near it and had probably spilled the arsenite of soda. In the case of the tree, one limb of which was dead, they had been more careful with their sodic arsenite, having some left over they determined to get rid of it and emptied it into the irrigating ditch near the tree; this was one day in June—two days later the limb was sick. I saw it in October when the limb was dead and had the appearance of having been dead for some time, and again in April last. In the meantime the limb had been cut off but was still lying beside the tree as shown in Plate VI. Mr. Whipple and I measured the distance from the trunk of the tree to the irrigating ditch shown in the foreground of Plate VI., and found it to be 12 feet. An examination of this tree showed that a section of the bark from the base of the trunk up into the big limb was brown, sunken and in appearance like the bark in the trunks of the affected trees. The wood beneath this bark was dead and colored brown, well shown in Plate VII., lower Fig. 2, which shows that nearly the whole section of the limb was involved, and that the bark was sunken and dead. The condition below the surface of the ground was even still more striking for the bark was destroyed and the little that remained was very dark, in places, black. We dug out this root, following it to the irrigating ditch, to the point where the sodic arsenite had been emptied. Two or three feet from the ditch, the root had divided into five branches or rootlets. These were black and brittle. Following these toward the trunk, we could trace the effect of the arsenite by two sections of the bark, one on the upper and the other on the lower side of the root, which had been destroyed and the wood beneath them killed

and blackened. The other two sections of the root were still of a natural color. The roots, two in number which were thrown off to the left of the main root presented a condition contrasting very sharply with the five rootlets and the two sections of the main root for they were apparently entirely normal while the others were black and dead. The condition of this root is shown in Plate VII., Fig. 1, which represents a section of the root taken close to the trunk of the tree—again in Plate VII., Fig. 4, which represents a view of the under side of a piece of this root. The side root was apparently healthy (Plate VII., Fig. 3). The killing of the bark and woody tissue was in this way traced from the point at which the sodic arsenite was introduced into the ditch through the small roots into the large one, thence into the trunk, the limb, and even into the branches. The course was direct and the flow of the poisonous solution was confined to a comparatively narrow channel. The darkened area, "black heart," in the case of these branches is shown in Plate VII., Fig. 1-a and upper Fig. 2, which shows the central discolored area, which is not symmetrical with the annual rings or contour of the limb, and also the border of deeper stained tissue. I am not concerned about any theory of sap circulation, but am simply tracing the discoloring effect of the arsenic through the root into this portion of the branches. We see that the discoloration extends through the root, trunk and central portion of the branch. In this instance, death may be said to have been sudden and it may be assumed that a portion of this effect may be a post mortem one.

We have not simply assumed that the placing of sodic arsenite in the ditch and the dying of this branch of the tree two days later are wholly conclusive as to the cause of death. I have examined the wood of the branches and the root and find an abundance of arsenic in both. In this case, I recovered the largest amount or arsenic found in any sample, namely from the discolored portion of the root, in which I found arsenic corresponding to 34.5 parts of arsenic acid in one million parts of the tissue.

The other portions of this tree were apparently in good condition when I last saw it. An examination of the branches from the unaffected portion failed to show any such case of "black heart" as the affected limb (Plate VII., Fig. 1-b). In fact, they showed nothing which could be classed as a darkened center, though I recall one branch which was clouded more or less.

I have given this case in some detail because I believe it to be as conclusive proof as can possibly be adduced that soluble arsenic compounds not only produce death when introduced into the circulation of the apple tree, but will produce the effects which we find preceding the death of our apple and pear trees. In both cases, we have the killing of the bark, the staining and destruction of the tissue, and the killing of the trees. The "black hearted" condition is

only incidental but in the case of our trees, I believe it to be a very suspicious condition.

I have now given the reasons for my conviction that the arsenic which has accumulated in our soil from the use of arsenical sprays used in combatting the codling moth and other fruit, leaf and bark eating insects is the cause of this trouble. To restate them succinctly, we find the arsenic already accumulated in the soil to an extent far beyond the danger line for solutions as established by competent experimenters. We find it also in the tissues of the plant where it is not normally present; we have proven both in the case of herbaceous and woody plants that soluble arsenical compounds will cause their death.

I regret that I can see no other conclusion than that the corroding of the crowns, the killing of the bark, the staining and final destruction of the woody fiber, the early dropping of the leaves presaging the early death of the tree and its final death a few months later are caused by arsenical poisoning.

SOLUBLE ARSENIC IS PRESENT IN THE SOIL.

In preceding paragraphs, I have made two statements which will help us to explain but in no wise to remedy the trouble. One statement is that the only protection against arsenical poisoning of our orchard trees is the insolubility of the arsenical preparations used in spraying and that their continued immunity from poisoning requires that these arsenical compounds shall not be rendered soluble by any agent in the soil. Again, also in an introductory paragraph, I state that from the standpoint of my own department, this subject was really approached through the study of the effects of the alkalies.

It is certainly true that it is possible that in time, these arsenical compounds might accumulate in the soil to a sufficient extent to enable the feeding roots of the tree to bring enough arsenic into solution to be dangerous to the life of the tree by systemic poisoning. It is useless, however, to dwell upon this possibility when there are known conditions, amply sufficient to explain all the facts. Our soils, especially near the surface, contain from 0.20 of one per cent to upwards of one per cent of alkalies, from 8,000 pounds to upwards of 40,000 pounds of alkalies in an acre foot. A few small areas may be practically free from these salts, but the rule is that they are present. It may be accepted as essentially correct that these salts consist of sodic sulfate and sodic chlorid. There is almost always a small amount of sodic carbonate present, but it is sometimes absent, as is the case in one of the soils in question.

ALKALIES RENDER ARSENIC SOLUBLE.

These so-called alkali salts, sodic-sulphate, carbonate and chloride or to call them by their more common names, Glauber's Salt, Sal Soda, and ordinary kitchen salt, are capable of bringing

the arsenic into solution, even when it is present as lead arsenate. It has often been asked at meetings of these orchardists whether it was a safe practice to use their surface alkali water in applying the lead arsenate and I have stated that it was not a good practice, for one could easily conceive of conditions under which the whole of the lead arsenate could be converted into sulfate of lead and sodic arsenate be formed in the solution. This statement never seemed to be an acceptable one. I have in this case not depended upon any chemical laws, however, evident their adequacy might be, but took well washed lead arsenate, a sample which we found by rigid test to be free from soluble arsenic, suspended one gram of it in 2,000 times its weight of water and added two grams of Glauber's salt, allowed it to stand three days, filtered off a portion of it, concentrated by evaporation and tested it for arsenic. I found that the arsenic had gone into solution in very considerable quantities. A parallel experiment was carried out with salt in which only one gram of salt was used to the 2,000 grams of water. This was not allowed to stand quite three days when 1,500 grams were filtered off, concentrated and tested for arsenic. This concentrated solution was found to be so heavily charged with arsenic, that only a small part of it gave an unmanageable amount of arsenic when brought into an active Marsh apparatus.

A similar series of experiments was made with the lime arsenite. We included in this experiment the salts above mentioned and also distilled water; the lime arsenite was prepared by precipitating a solution of calcic chlorid containing an excess of the lime salt with a solution of arsenite of soda, filtering and washing it. This precipitate was probably the pure normal arsenite of lime. One gram of this lime arsenite was suspended in 2,000 times its weight of distilled water, another gram in a like quantity of water containing two grams of Glauber's salt and a third gram in a like quantity of water to which had been added one gram of salt. The calcic arsenite seemed almost completely soluble in each of the three trials.

We have then direct proof that the alkali salts in the soil are capable of bringing the arsenic, even when present as arsenate of lead, into solution and consequently making it a source of danger.

In regard to the arsenite of lime, there would seem to be but little to be said. I remember having years ago tested the clear solution remaining after the lime and arsenite of lime had settled and as I now recall it, for I have no note on it, the solution was free from arsenic. If this is correct it may have been due to the great excess of lime present.

LIME SALTS IN THE SOIL DO NOT PREVENT THE SOLUTION OF ARSENIC

The idea expressed in the last sentence has persistently presented itself in another form, namely would not the lime salts oc-

curring in our soils, especially gypsum which is notably soluble in water, serve to prevent the solution of arsenic. The answer to this is unquestionably no. For when 500 grams of soil, rich in sulfate of lime, were suspended in 2,000 grams of water and allowed to stand, some arsenic went into solution. This experiment was made three times and the results showed the presence of soluble arsenic so decidedly that there was no reason to seek even for cumulative evidence on this point. It does not, of course, matter where the alkalies came from, whether they were already in the soil or whether they are brought to the soil by the water used for irrigation, some of which I know to be rich in alkali.

CANNOT DISTINGUISH THE SOURCE OF ARSENIC.

I do not know the history of the samples of soil examined whether they contained the arsenic as lime arsenite or lead arsenate, nor does it appear to me to be a matter of importance in which form the arsenic was present in the soil. The experiments with the alkalies, Glauber's salt and ordinary kitchen salt, indicated in my judgment, the greater solubility of the lime salt, but it would be difficult perhaps, aside from the deportment of the lime salt, to prove directly that the arsenic found in the tree had been derived from the lime arsenite for the ash of the tree contains some lime and there is scarcely an orchard soil which has not received both the lead and lime salts. It is impossible to tell which one has contributed more largely to the damage done, but owing to the length of time it has been used and the greater readiness with which it appears to go into solution, it would seem probable that the lime preparation has up to the present, contributed more largely to bringing about the trouble than the lead salt.

It is, on the other hand, easier to obtain direct proof that the lead arsenate has been the source of some of the arsenic for lead is not a normal constituent of woody tissue and the presence of a trace of it suffices to prove that the lead arsenate has been the source of the arsenic. I tested only six of the samples for lead but as lead was found in each of them this number of tests is deemed sufficient. The lead was obtained in the metallic form and its identity established beyond doubt.

The significance of this is not only that lead arsenate has been the source of the arsenic but that the ordinary kitchen salt present in the soil is probably an active agent in bringing it into solution, for the lead chlorid which would be formed by the interaction of the lead arsenate and salt is more readily soluble than the sulfate, the product of the interaction of Glauber's salt and lead arsenate. In this case too, it seems beyond question that both salts, Glauber's salt and ordinary kitchen salt, contribute to the damage done. The amounts of these salts in the soil and in some water used for

irrigation, particularly the Glauber's salt, is more than ample to bring about the solution of the arsenic.

TWO KINDS OF ARSENICAL POISONING.

So far I have not mentioned the character of this arsenical poisoning whether it is a general systemic poisoning or a case of acute irritant poisoning. That the former class of poisoning may occur seems very probable as in the case of one of the pear trees studied but all the rest of the cases with which we have met so far, seem clearly to belong to the latter class. The possibility of the occurrence of the former, however, is a matter for serious concern, for if the soil becomes sufficiently rich in arsenical compounds to enable the roots to appropriate the arsenic as they do the general sustenance of the tree then the poisoning of the tree becomes a question of its ability to tolerate the poison. I fear that we have some cases in which our statement that the beginning of the trouble is at the crown of the tree, is not applicable, though this, as a rule, seems to be the case. Still it is suggestive, as elsewhere indicated, that often the dead roots are not as intimately connected with the affected areas of the crown as those which still retain a little life.

The lead and lime with which the arsenic is combined in the sprays may be appropriated by the tree to its injury. The amount of lime, however, added to the soil as lime arsenite would be wholly insignificant in comparison with the lime already present in nearly all of the soils with which we are concerned in this bulletin unless it were taken up as arsenite of lime.

There are really three substances which might act as poisons to the trees, namely, arsenic, lead and lime.

ARSENICAL POISONING.

I have already discussed the question of arsenical poisoning so far as the purposes of this bulletin demand.

LEAD POISONING.

The question of lead poisoning is a permissible one for discussion, but while lead, as it was found in every sample tested for it, is probably present in all of the samples and may have some influence, the action of the arsenic appears so clearly the important one that the action of lead may be dismissed with this brief mention.

THE EFFECT OF LIME.

This question is one which cannot justly be left wholly without mention. As indicated above the lime and arsenic may be taken up in combination, or it may be simultaneously but not in combination and it would be difficult to distinguish their separate action. There are, however, other questions which involve the case

still further. It is stated on good authority that marly soils are unfriendly to a number of plants. Many of our soils are rich in carbonate of lime and others are underlaid by a stratum of marl, carbonate of lime, sometimes acquiring a thickness of two feet or more. It is a serious question in my mind whether this is not a bad feature. My attitude toward this subject is exactly the same as that toward the one or arsenical poisoning, i. e., that the subject should not be mentioned without good and forcible reasons for doing so. Why mention this then at all?

I have called attention to the fact that many trees, evidently in an unhealthy condition, are bleeding freely from old wounds, stubs, where limbs and branches have been cut off and from cracks in the bark (Plate V., Figs. 1 and 2). This sap is heavily laden with salts of some kind, dries quickly, and deposits a yellowish white crystalline mass. This mass when fresh possesses, at least sometimes, a disagreeable taste; the thoroughly dried salt has not a particularly unpleasant one. I have seen this juice dripping from a crack in the bark and building a veritable stalactite of this material. Mr. Weldon, our Field Entomologist, and I gathered a quantity of this material, avoiding as far as possible the scraping of the bark, lest we should get some of the spray material. The conditions exposed our sample to contamination in this manner and by dust, which might contain arsenic, being blown into it, but I think that the results obtained from this sample may be accepted as, in the main, reliable. This material was very rich in arsenic and contained 25 per cent of calcic oxid. I do not believe that the splitting or cracking of the bark and the bleeding are specific characteristics of arsenical poisoning but are attributable to other causes which in these cases may act conjointly with the arsenic. The destruction of the bark by the arsenic is an entirely different thing from this cracking or splitting of the bark.

Having found that this dried sap was an interesting subject, we gathered a second sample. The preceding sample was gathered before the first spraying of the season had been made, but the second was taken subsequently to it. Lead arsenate was used in the spray and might have gathered in this dried juice which forms rough masses on the limbs and trunk of the tree. In order to remove as far as I might be able, such arsenic as might be present as lead arsenate, dust and other impurities, I dissolved the dried sap in as little warm water, not boiling, as possible and used only the aqueous solution in making the test for arsenic which was very abundant indeed.

This sample of air-dried material gave 24.93 per cent of lime, CaO; it contained a little magnesia and alkalies. I have made no attempt to determine the acid combined with the lime, but lime being practically the only base, it seems probable that the mass is essen-

tially a malate of lime which would require 25.7 per cent of this substance, calcic oxid. These trees do not present the symptoms described for the arsenical poisoning, though arsenic is very abundant. The question is—Are these trees suffering from systemic arsenical poisoning, lime poisoning or both? These soils are marly or have a subsoil of this material and the presence of 25 per cent of lime in the dried sap seems to me to be a very suggestive fact.

I have no remedy to suggest for either condition. Preventive measures are so far as I can see, our only recourse. Those which suggest themselves to me are: to remove the arsenic laden soil from about the crown of the tree and replace it with fresh soil; to use the standard brands of lead arsenate in preference to the arsenite of lime or white arsenic, sal soda and lime; to use as little lead arsenate as possible. I have been told that good results have been obtained by using 2 1-2 and even 2 pounds of pasty lead arsenate to 100 gallons of water, but the spraying must be done thoroughly. Spray no oftener than is absolutely necessary. If I am not mistaken Prof. Gillette has found that 95 per cent of the effect of the whole season's spraying was obtained by the first spraying when thoroughly well done. Some device should be used to prevent the spray material from running down the trunk and collecting at its base or it would be still better to make provision for gathering the whole of the drip. Water rich in alkalies should not be allowed to flow close enough to the tree to permit of the deposition of the alkalies in the soil about the trunk of the tree. Concentrated lye, if used to kill the woolly aphis, should not be applied to the soil at the crown of the tree or permitted to flow down and collect there.

SUMMARY

First: There is a large number of fruit trees in the State which are suffering from an affection of the trunk and root.

Second: This trouble begins, in by far the greater number of cases, at the crown of the tree and subsequently involves both trunk and roots.

Third: The first marked symptom is an early ripening of the foilage usually followed by death about midsummer of the ensuing year.

Fourth: The crown of the tree is found to be girdled, the bark on portions of the trunk dead and sunken and most of the roots dead, their bark destroyed and the woody tissue discolored, usually a light shade of brown and sometimes exteriorly blackened.

Fifth. Soluble arsenical compounds will effect the destruction of the bark, the staining of the wood, the production of the so-called "black heart" and the speedy death of the tree.

Sixth: Arsenical sprays have been used in these orchards for a number of years.

Seventh: These arsenical compounds have accumulated in the soil.

Eighth: The accumulation of arsenic in the soil in an insoluble form has already passed far beyond the limit of danger for arsenic in a soluble form.

Ninth: The insoluble arsenical compounds are being converted into soluble ones in the soil.

Tenth: The alkalies are the agents effecting the solution of the arsenic. By alkalies, I mean, sodic carbonate, sodic sulfate and sodic chloride.

Eleventh: The lime salts, viz. the sulfate, gypsum, and the carbonate do not effectively protect the arsenical compounds from the solvent action of the alkalies.

Twelfth: Systemic poisoning may take place, probably does, by absorption of the arsenic with the nutritive solutions taken up by the feeding roots but the greater portion of the trouble appears to be from local irritant poisoning.

Thirteenth: The arsenical poisoning is, in all probability, in many cases, complicated by lime poisoning.

Fourteenth: The arsenic in the arsenite of lime is more readily brought into solution than that of the lead arsenate.

Fifteenth: It is probable that the lime or marl in the soil and subsoil is also an agent acting conjointly with the arsenic in producing some of the trouble.

Bulletin 132. Sept. 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Destruction of Concrete by Alkali

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		TERMS EXPIRE
HON. JAMES L. CHATFIELD	Gypsum	1909
HON. B. U. DYE	Rocky Ford	1909
HON. B. F. ROCKAFELLOW, *President*	Canon City	1911
HON. E. H. GRUBB	Carbondale	1911
HON. R. W. CORWIN	Pueblo	1913
HON. A. A. EDWARDS	Fort Collins	1913
HON. F. E. BROOKS	Colorado Springs	1915
HON. J. L. BRUSH	Greeley	1915

GOVERNOR HENRY A. BUCHTEL,
PRESIDENT BARTON O. AYLESWORTH, } *ex-officio.*

A. M. HAWLEY, SECRETARY — CHAS. SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director* ..... IRRIGATION ENGINEER
C. P. GILLETTE, M. S. ..... ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D ..... CHEMIST
WENDELL PADDOCK, M. S. ..... HORTICULTURIST
W. L. CARLYLE, M. S. ..... AGRICULTURIST
G. H. GLOVER, M. S., D.V. M ..... VETERINARIAN
W. H. OLIN, M. S., ... AGRONOMIST
W. G. SACKETT, B. S ..... BACTERIOLOGIST
R. E. TRIMBLE, B. S ..... ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S ..... ASSISTANT CHEMIST
EARL DOUGLASS, M. S ..... ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S ..... ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S ..... ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S ..... ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S ..... ASSISTANT AGRONOMIST
P. K. BLINN, B. S ..... FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S ..... POTATO INVESTIGATIONS
MIRIAM A. PALMER ..... ARTIST
L. C. BRAGG ..... ASSISTANT IN ENTOMOLOGY

STATE FRUIT INVESTIGATIONS:

O. B. WHIPPLE, B. S., Grand Junction ... FIELD HORTICULTURIST
GEO. P. WELDON, B. S., Delta ..... FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S. ..... DIRECTOR
A. M. HAWLEY ..... SECRETARY
MARGARET MURRAY ..... CLERK

Destruction of Concrete by Alkali.

BY

WM. P. HEADDEN.

Cement has been found so generally serviceable and beset with so few disadvantages that its use is generally recommended without any reservation, and this confidence has been fully justified with but few exceptions so far as the limited literature at my disposal indicates.

The principal condition under which good portland cement has failed to fulfill the requirements of the structure in which it was used, seems to have been where the structure was exposed to the action of sea water. Such exposure has not resulted uniformly in the destruction of the cement, so that even this condition, i.e., the exposure to sea water, a solution comparatively rich in magnesic chlorid and sulphate, may not have been the determining factor in the trouble noted.

The following case of deterioration may be of some interest as it presents some new points. There were sent to me some months ago a number of fragments of tiling which had been laid but from eight to nine months. They had been disintegrated to such an extent that one of the samples was simply a white putty-like mass mixed with sand. There was nothing about this sample remotely suggestive of concrete. Another of the samples consisted of a fragment of the tile, the interior portions of which had been wholly decomposed, while there still remained an outer and inner portion in good condition, or comparatively so. Another sample had been attacked on the inner side leaving the mass of the tile outside of the zone of decomposition apparently sound. The line of decomposition was sharply limited and showed distinctly, but even in this case there remained a thin layer of cement on the inside.

I do not know whether the tile were running full of water or not, probably not, as the fragments seem to be parts of 16 or 18 inch tile. The importance of this point is simply this, that it would answer any question in regard to the separation of solid "alkali" salts on that portion of the tile above the water line. That such a separation of these salts should take place does not seem very probable in this case.

The point of attack so far as the samples at my disposal indicate, is either in the center of the cement mass or near the inner surface. In either case we are almost compelled to assume the action of the water, i. e., of the salts held in solution. At the same time we see the resisting power of the outside and inside surfaces, which are evidently richer in cement than the inner portion of the mass of the tile.

The sand used in making the tile was quite fine.* The proportion used was 5:1. We can readily see that the individual masses of cement in the interior mass of the tile must be small and readily attacked by solutions of salts capable of reacting with the cement.

It seems quite evident that the agents causing this disintegration of the cement must gain access to the interior portion of the mass of the tile

*I do not know the character of the water used.

in the form of a solution, but it is a question whether this solution is the same in strength and character as the water in the drain. I think that I have clearly shown in Bulletin 65 of the Colorado Experiment Station, page 34, that the water soluble portion of the soil is different from the salts held in solution in the ground water. Further in Bulletin 72, page 28 **et seq.** that the ground waters are different from the drain waters, and the action of these waters on the tile would vary somewhat according to the source of the solution which penetrated the mass of the tile.

The drain waters obtained, say at a depth of four feet, contain as a rule a smaller amount of salts in solution than the ground water. The salts present are the same but their relative quantities vary. The usual salts present in the ground waters are, sodic sulfate, calcic sulfate, magnesic sulfate, sodic carbonate, and sodic, in some instances also magnesic chlorid. In the drain waters we have the same salts but their relative quantities are different, the most notable feature being the relatively large amount of sodic carbonate.

The substances claimed to be the most active in effecting the disintegration of cement are the sulfates. In the case of sea water the explanation offered is that the lime of the cement decomposes the magnesic salts present in the water whereby the lime goes into solution and the magnesia is deposited in its stead, causing a bulging and disintegration of the work owing to its greater bulk. The principal magnesian salt in sea water is the chlorid, the deleterious action of which on cement is not established, but it has been shown that magnesic sulfate acts energetically.* The most active agent in decomposing concrete is the sulfuric acid of the sulfates carried in solution. Again solutions of gypsum have been shown to act detrimentally on concrete by forming with the tri-calcic aluminate a sulfo-aluminate.

The water acting on these tiles whether it be ground water or drain water is very bad. One of the two small samples sent to me contained 1252.6 grains per imperial gallon, of which 493.5 grains were sulfuric acid (SO_3) with an extremely large proportion of magnesia. The other contained 542.3 grains per imperial gallon, with 42.31 grains of magnesic oxid or 7.8 per cent. of the total solids. I have examined a number of waters from this section and find the ground water uniformly heavily laden with the sulfates of lime and soda with comparatively large quantities of magnesia, especially if the water comes from near the surface as it necessarily must in the case of drain waters. In addition to the above constituents, there is uniformly some carbonate present which for the present purpose we may consider as sodic carbonate.

We have then an ample supply of these substances present which are known to act deleteriously upon cement, i.e. the sulphates, a portion of which is magnesic sulfate, and in addition there is so much sodic carbonate present that its action cannot be neglected.

For the present I will assume that the cement used was at least an average Portland cement with not more than two per cent. of calcic sulfate added. Assuming this to be correct, the action of the waters on the tile shows an interesting line of action.

A preliminary examination of the white decomposition product indica-

*Taylor & Thompson Concrete Plain and Reinforced P. 401.

ted the presence of a large amount of water, also of considerable quantities of sulfuric and carbonic acids. The decomposed mass was washed with distilled water to remove as much sand as possible. Examination of the wash water showed that it had taken sulfuric acid, lime and soda into solution. The portion soluble in distilled water may have been partly derived from other sources but probably came, for the most part, from the altered cement. The wash water, therefore, was evaporated to dryness and the residue added to the insoluble portion and the whole dried at 60°C. The material thus prepared was submitted to analysis with the following results; with which is also given an analysis of a sample of the same brand of cement.

PORTLAND CEMENT DECOMPOSED BY ACTION OF ALKALI WATER

	Original Cement	Decomposition Product*	Same calculated on water free basis
SiO_2	22.55	10.98	14.16
SO_3	1.29	15.56	20.07
CO_2	1.07	9.39	12.16
Cl_1	not det'd	0.51	0.65
P_2O_5	.....	trace	.....
CaO	59.86	29.14	37.58
MgO	1.75	5.79	7.46
Al_2O_3	5.88	2.08	2.68
Fe_2O_3	4.83	2.51	3.23
Mn_3O_4	0.21	trace	.....
Na_2O	0.76	1.27	1.63
K_2O	0.63	0.29	0.38
H_2O Ignit. less CO_2	0.72	(22.48)	.....
	99.55	100.00	100.00

The loss on ignition in the analysis of the decomposition product agreed fairly well with that obtained by difference, but owing to the presence of alkalies, carbonates and sand the results of direct ignition are not to be relied upon except to show that the difference indicates the amount of water present with reasonable accuracy.

The composition of the water acting on this tiling may safely be assumed to be represented by the following analysis of a sample of Arkansas river water, essentially a return water, taken at Rocky Ford.

The summation of the analysis presents a rather large excess over one hundred which gives an excess of about one grain in the total amount of salts present. The excess of bases shown in the analysis as combined is not necessarily due to bad analytical work. The waters of our mountain streams show an excess of acids over the bases, but the alkalies forming efflorescences on our soils and alkaline waters, frequently show an excess of the bases, but seldom so large as in this case.

*6.01 per cent. sand deducted.

ANALYSIS OF ARKANSAS RIVER WATER, TAKEN AT ROCKY FORD

Total solids per imperial gallon 156.4 grains.

Analytical results.	per cent.	Combined	Grs. Imp. Gal.
SiO_2	0.428	Calcic sulfate	64.942
SO_3	48.299	Magnesic sulfate	27.994
CO_2	1.858	Potassic sulfate	0.942
Cl	4.667	Sodic sulfate	32.449
Na_2O	18.662	Sodic chlorid	12.044
K_2O	0.326	Sodic carbonate	7.007
CaO	17.090	Sodic silicate	1.358
MgO	5.993	Ignition	6.797
Ignition	4.346		
Sum	101.669	Sum	153.533
Oxygen equiv. to Chlorin...	1.051	Excess sodic oxid	3.832
Total	100.618	Total	157.365

The ground waters of the Arkansas valley have essentially the same composition; they of course, vary in the amounts of mineral matter, total solids, held in solution. The two small samples of drain water sent with these tiles illustrate this very well, one of them carried 1252.6 grains, while the other carried less than one half as much, 542.3 grains in an imperial gallon.

The salient featurers in the composition of the salts present in the ground waters of this section are the large amount of sulfates and the presence of carbonates. The amount of chlorine or the corresponding chlorids is not large and are probably subordinate agents in the alteration of the cement.

Mr. R. Feret says*; "No cement or other hydraulic product has yet been found which presents absolute security against the decomposing action of sea water." Further, "The most injurious compound of sea water is the acid of the dissolved sulfates." Again the same writer says; "It is noteworthy, however, that chloride of magnesia is almost without action, while the sulfate of magnesia acts energetically upon cement. * * *"

It has further been established by Candlot, Michaelis and Deval working independently, that calcic sulfate unites with calcic aluminate forming a hydrated sulfo-aluminate which expands greatly on crystallizing and is soluble in water.

It is assumed that magnesic sulfate acts upon the calcic hydrate set free by the setting of the tri-calcic silicate, forming calcic sulfate which is then capable of uniting with the calcic aluminate with bad results.

The ground waters found in the lower portions of our irrigated sections contain a mixture of the sulfates of soda, lime and magnesia, with which there is usually associated some carbonate. Some of these waters are essentially solutions of sodic sulfate with a little sodic carbonate; others especially drain waters contain calcic and magnesic sulfates with some carbonate, possibly sodic carbonate.

*Taylor & Thompson Concrete Plain & Reinforced. P. 400.

The knowledge of the fact that our drain waters contain carbonates led me to try the action of a mixture of sodic sulfate and carbonate on the coarsely ground concrete. This mixture attacked the cement rapidly yielding a white decomposition product rich in carbonic acid. This result is no other than what we would expect. If the tri-calcic silicate in setting really liberates four molecules of calcic hydrate, as we suppose the reaction should be accompanied by the liberation of a corresponding amount of sodic hydrate. The following formulae will make this point clear:

$$2(3CaO.SiO_2)+9H_2O=2(CaO\ SiO_2)5H_2O+4Ca(OH)_2.$$

The calcic hydrate liberated or very loosely held can readily act on the sodic carbonate as indicated by the following simple formula;

$$4Ca(OH)_2+4Na_2CO_3=4CaCO_3+8NaOH.$$

The sodic hydrate thus freed is capable of further attacking the silicates and possibly the aluminates, carrying silicic acid, alumina and lime into solution, probably as hydrated silicates. The treatment of the cement with a mixed solution of sodic carbonate and sulfate showed that it is a fact that calcic carbonate is formed and also that silicic, alumina and lime do go into solution and that too without the aid of free carbonis acid.

No care was taken to make the solution of mixed salts even approximately of the same strength, as the ground waters, and no ratio between the salts was observed, simply, that the solution was a weak one; two to three grams of sodic carbonate to the liter with five or six grams of the sulfate The time of the experiment was 14 hours. The time was short, and the solution not as rich in salts as some of our ground and drain waters. The tiles on the other hand are exposed to the action of similar solutions, some weaker but others stronger from the time of being laid till taken out, in this case eight to nine months. In view of these considerations it is not strange that the mass of concrete should be softened and destroyed.

Using the results of these rather crude experiments we may interpret our analyses as indicating that the cement has been deprived of silicic acid; it originally contained 22.50 per cent. but the hydrated decomposition product contains only 10.98 per cent or 14.16 per cent calculated on a water free basis. While the ratio of the weight of the decomposition product to the original weight of the cement is not known, there is no evidence that there has been any increase in the weight which would invalidate the preceding observation and a second experiment with cement and a solution containing sodic sulfate and carbonate leaves no question about the removal of silicic acid, alumina and lime by waters containing these salts. The analyses also suggest the removal of a relatively large amount of lime. The cement contains 59.56 per cent. of lime while the alteration product contains but 37.58 per cent. (calculated on a water free basis). Further the ferric and aluminic oxids have been reduced to about one half as much in the decomposed cement as there was in the original. The sodic sulfate, more particularly the calcic and magnesic sulfates which are present in the ground water will at the same time act on the tri-calcic aluminate, forming the sulfo-aluminate $2(3CaO\ Al_2O_3)+5CaOSO_3$, which crystallizes with 60 molecules of water and is soluble. That these reactions really have taken place is indicated by the increase of the sulfuric acid SO_3 which amounts to 20.07 per cent. and likewise of the carbonic acid which amounts to 12.16

per cent. of the water free decomposition product, while they amount to only about 1.0 per cent. each in the original cement.

That the magnesic sulfate also participates in producing the deterioration is indicated by its presence in the altered cement to the extent of about five times the amount present in the original; i.e. 7.46 per cent. in the water free alteration product against 1.75 per cent. in the original.

The changes effected in this case are quite consonant with the views quoted excepting the formation of so large a proportion of carbonate, evidently calcic carbonate due to the action of the sodic carbonate in the ground water. The presence of sodic carbonate in a solution so rich in lime may seem improbable, but this has been shown to be not only possible, but a fact.

This alteration product differs materially from those produced by the action of sea water on the works at Aberdeen and analyzed by Prof. Brazier (Redgrave and Spackman, Calcareous Cements. p. 285.) according to which the chief decomposition products were calcic carbonate with calcic and magnesic hydrates, while the amount of the sulphuric acid was scarcely altered at all. The analyses indicate a removal of the ferric and aluminic oxids from the interior portions of the work, and an increase of them in the outer portions. The authors after giving the analyses justly make the following statement: "We may observe with respect to these analyses that both in the case of the original cement and the deteriorated concrete, there are many matters which we are quite unable to reconcile."

The action of the ground waters seems to have been one of chemical change converting the lime of the cement into a sulfate and carbonate accompanied by the removal of silicic acid, alumina and lime and totally destroying the cohesiveness of the concrete.

The samples of deteriorated tiles sent to me do not justify any inferences whatever in regard to the part that may have been played by the expansive force of newly formed crystallizable compounds. The thickness of the tile and the amount of material involved is so small that this factor is negligible and the results presented are probably wholly due to chemical action.

This subject is of some importance as concrete structures, bridges, culverts, foundations, etc., are being erected in places where they will be subjected to the action of such waters.

Most of the cretaceous shales are, so far as my observation goes, rich in alkalies, calcic sulfate, etc., and concrete foundations laid in these may be acted on prejudiciously.

As the work in this article was about completed, I received Bulletin 69 of the Montana Experiment Station. The attention of the writers of this bulletin, E. Tappan Sannatt, and Edmund Burke, was called to the deterioration of the cement mortar used in the construction of the sewer system of Great Falls, Montana, by the City Engineer, C. W. Swearinger.

This bulletin gives some excellent illustrations of deteriorated mortar and a general description of the conditions as they found them, also some suggestions relative to their local conditions and recommendations in regard to foundations and other structures made of concrete, but there is no chemical work done on the cement and the products of its alteration. Such work is promised for some future time.

Bulletin 133 Sept. 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

A Few Orchard Plant Lice

BY

C. P. GILLETTE
AND
E. P. TAYLOR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915
GOVERNOR HENRY A. BUCHTEL, } *Ex-Officio.*		
PRESIDENT BARTON O. AYLESWORTH, }		

A. M. HAWLEY, SECRETARY — CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*,	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.,	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
W. H. OLIN, M. S.,	AGRONOMIST
W. G. SACKETT, B. S.,	BACTERIOLOGIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOUGLASS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSON, M. S.,	ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S.,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS
MIRIAM A. PALMER,	ARTIST
L. C. BRAGG,	ASS'T IN ENTOMOLOGY

STATE FRUIT INVESTIGATIONS

O. B. WHIPPLE, B. S., GRAND JUNCTION,	FIELD HORTICULTURIST
GEORGE P. WELDON, B. S., DELTA	FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

A FEW ORCHARD PLANT LICE

C. P. GILLETTE AND E. P. TAYLOR*

Among the worst insect enemies of the Colorado orchadist today are a few species of plant lice. The codling moth used to be our queen of orchard pests, but the apple growers have learned to successfully combat this insect by means of arsenical sprays.

The plant lice, or aphids, illustrated and discussed in these pages, are not the only ones that fruit growers have to contend with, but they are the species needing the closest attention at the present time in Colorado orchards, and when one has learned to combat these, he will be able to apply the proper remedies for the destruction of most other kinds that he is likely to come in contact with. It has been thought best to give a rather full account of the life habits of the lice here mentioned so that the fruit grower may better understand the methods of control.

The colored plates have been prepared at considerable expense that the reader may better recognize these pests. We believe the bulletin will help those who read it to understand that different plants have different species of lice infesting them, and that these lice often have very different life habits and require different means of control. The lice that infest any plant never appear spontaneously, but every louse, like every higher or larger animal, is the offspring of a parent of the same kind. Consequently all the lice that infest our plants were either native, living upon Colorado wild plants before white men came here, or they have been carried to our orchards upon nursery stock from other parts of the world.

GENERAL STRUCTURE AND HABITS OF THE PLANT LICE (*Aphididae*).

There are a large number of species belonging to the group of insects commonly designated as "aphids" or "plant lice," which have a remarkable similarity of structure and general habits. A knowledge of the more important structural characters of these

*The general direction of the studies here reported, the determination of species, all descriptions, and many of the field and insectary records were made by the writer of this note. The extensive field experiments with remedies upon the Western slope, as well as many life history and food plant notes, were made by Mr. E. P. Taylor, while acting as Field Entomologist for this station. A large portion of the life history and food plant notes, both in the field and in the insectary, have been by Mr. L. C. Bragg. The illustrations are all by the department artist, Miss M. A. Palmer, with the technical descriptions before her. Miss Palmer always draws from her own measurements of parts and when her measurements and mine do not tally, we reach a joint agreement before she proceeds. So I believe the drawings will be found, structurally, quite reliable.

The technical descriptions, with some additional notes upon life habits, have been sent to "Journal of Economic Entomology" for publication.—C.P. GILLETTE.

lice is necessary to enable one to distinguish the species from one another or to understand the descriptions. A knowledge of the general habits will be of great service in enabling one to decide what remedies to employ for the destruction of any of these lice when found infesting plants in general.

EXTERNAL STRUCTURE OF THE APHIDS.

The more important structural parts of an aphis are clearly shown in Fig. 1. The antennae upon the head are special organs of touch and probably smell also. By means of them the insect is able to find its food plants and its mates. The cornicles, standing out from the posterior part of the abdomen, are little tubes through

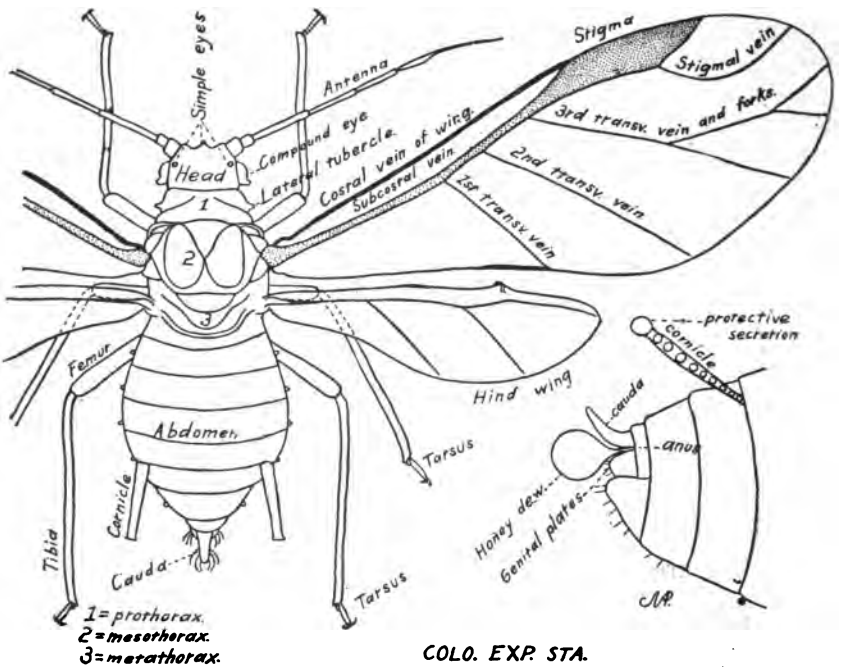


Figure 1. External Structure of an Aphis.—M. A. Palmer, artist.

which the louse expels a sticky material of various colors in different species, as green, yellow, red, black, white, etc. This secretion is probably for the purpose of defense against enemies, but these organs are never for the purpose of expelling the little clear drops of "honey dew" which are so eagerly sought after by ants and sometimes flies, bees and wasps, for food. The honey dew is expelled from the anal opening beneath the cauda, as shown in the smaller drawing, Figure I. The beak, through which the lice

suck the sap of plants, is beneath the head and does not show in the figure.

Each species of plant louse has its special food-plant or plants upon which it feeds. Some species are very restricted in food, having but one, or at most a very few closely allied plants, to live upon, while other species have a few preferred plants but also attack others in smaller numbers, and under certain conditions may adopt a very wide range of plants, especially in the spring, when nearly all growth is tender and succulent, and again in the fall after the preferred food plants may have ripened or have been killed by frosts.

Perhaps one of the most important things to be known, from an economic standpoint, is that very many plant lice have a regular alternation, or change, of food plants. Such lice usually migrate upon certain trees or other woody plants in the fall, upon which eggs are deposited to remain over winter and hatch in the spring to start the next year's broods. These spring forms, after going through one or more generations, acquire wings and go, either wholly or in part, to their summer food-plants, which are usually plants that will die down in the fall.

But it is a condition that we face. The lice are in our orchards. How can we recognize them? What are their habits? How can we prevent their injuries to the fruit crops? These are the questions we shall specially attempt to answer, for the fruit growers.

APPLE PLANT LICE

THE WOOLY APPLE APHIS

(*Schizoneura lanigera* Hausm.).

Plate I, Figs. 9, 10, 11, and Plate III, Figs. 3, 4.

If Colorado orchardists should vote their opinion as to what ought to be called the worst orchard pest in the state, it is very doubtful whether the codling moth, or the woolly aphis, would carry off the honors.

Most plant lice are leaf feeders, but this one confines its attacks to the tender bark, and it is not particular whether it is the bark of the trunk, limbs or roots, if it is only tender enough to enable the louse to insert its beak. When very abundant the lice sometimes attack the stems of the leaves and fruit.

PAST HISTORY.

No one seems to have determined with much certainty the native home of this insect. In fact, it may be said to be a louse without a country, as it is everywhere disowned. The earliest references to it that we have found dates back to 1787, when it was

reported upon apple trees in England. Harris, in his "Insect Injuries to Vegetation," states that the louse had been known in France several years earlier than this. In 1801 it was reported in Germany by Hausmann, who described it and gave it its scientific name. In 1810 it had become so abundant in Gloucestershire, England, that the farmers feared they would have to stop making apple cider, and it is still a serious pest there. In England it was early believed that this insect was first introduced upon nursery stock from America. Buckton, an English writer, in his "Monograph of British Aphidides," seems to believe that this louse is a native of America, and states that it has been known to occur upon the American crabapple;* but the first record we have of the occurrence of the woolly aphis in the United States is in Harris' "Insects Injurious to Vegetation," published in 1841, more than a half-century after it had become a recognized pest in Europe.

In England, before the real cause of the mouldy appearing trees had been discovered, this malady was called American blight. On account of the blood red stain, caused when this louse is crushed, the Germans have called it the blood-louse. But wherever this insect may have its native home, and whatever may have been its native food plants, we know that it now occurs in practically every apple-growing region on the globe and, as it is an insect of much economic importance in Colorado, we shall go rather fully into its habits, life history, and means of control.

THE LOUSE DESCRIBED.

Most orchardists will think a description unnecessary, and to them it would be were it not for the fact that there are many other woolly lice upon other plants that are frequently mistaken for the woolly aphis of the apple.

The name woolly aphis was given because of the white secretion occurring so abundantly upon the wingless lice, and, to some extent, upon the winged ones also. This is not a woolly covering in the sense that it grows like wool or hair. It is really a fatty or waxy secretion similar to the shellac, China wax, or beeswax of commerce. Small glands beneath the skin give off delicate white threads of this material through minute pores. This white secretion, when warmed, will melt like tallow. It is easily removed from the body, but in a short time the body will be covered again. It serves as a protection to the louse against storms, and, to some extent, no doubt, from its insect enemies.

*Buckton probably had in mind the statement made by Fitch in his first N. Y. report, p. 5, in which he says he has seen the winged form of the woolly aphis numerous in groves where he suggests that it had come from the shad-bush (**Amelanchier sp.**). It is altogether probable that Fitch mistook the winged form of **Pemphigus corrugatus** Sirr. for winged migrants of the woolly aphis of the apple.

The body beneath the wool is of a rusty or purplish brown color in the fully grown lice, but the very young are much lighter colored. The winged lice are recognized in patches of the white secretion by their long, dusky wings. The thorax and head are black, or nearly so; the abdomen is a dark yellowish brown, and the legs, eyes and antennae are also black or blackish. The last lice in the fall, those that live over on the tree above ground (Fig. 11), are of a dark yellowish to dusky brown color, without the cottony secretion, and would not be recognized as the same insect at all by one not familiar with this stage in the life history of this insect.

LIFE HISTORY.

The life history of this pest of our apple orchards is most wonderful, some stages of which are still not well worked out. Upon the roots, the wingless lice may be found in all stages of development at any time of the year, reproduction and growth taking place more slowly or ceasing entirely in cold weather. Apparently the weather is never cold enough to kill the lice that are well beneath the surface of the ground. We have occasionally found winged lice beneath the surface of the ground when digging about the roots of trees, but we have never found the true males or females or eggs upon the roots. So the lice are always carried through the winter in large numbers upon the roots of the trees, and many of the small lice have often been seen in the spring and early summer migrating up the trunks of apple trees, some of which, undoubtedly, lived over winter upon the roots, or are the offspring of those that did. This does not mean that there is anything like a general migration of the root-lice upward in the spring, for we have no reason to think that such is the case. Neither do lice that are half-grown or more seem inclined to change their locations. Only the very young seem to travel about.*

Upon the trunks and branches of the trees we have, then, four possible sources of the lice in the spring; the little brown lice that descended mostly to the crowns of the trees in the fall to spend the winter; lice from the roots, whose ancestors lived upon the roots the previous summer; young lice of the last fall brood that were able to withstand the rigors of the winter upon the trunk and branches, and lice hatching from eggs that were deposited the previous fall by the sexual females.

From our observations, the most important of these sources is the first mentioned, and the least, if of any importance at all,

*Since writing the above, a letter from Mr. George P. Weldon, Field Entomologist, located at Delta, Colo., dated June 25, '08, says: "I notice only very small lice are trapped in Tanglefoot bands, indicating that the larger ones do not migrate at all."

the last one. Much careful observation has not rewarded us by the finding of a single sexual male or female or an egg of this louse out of doors upon an apple tree under normal condditions. Professor F. V. Theobald, of the South-Eastern Agricultural College, at Wye, England, in his "Report on Economic Zoology," 1907, says: "The egg stage takes place close to the base of the tree, always, however, above ground level. These ova remain frequently hidden in the crevices of the bark all the winter, and in spring they produce a larva which soon matures into the 'mother-queen' form, and which sets to work at a great rate to produce viviparous young." Whether Professor Theobald is reporting his observations or is reasoning from analogy we are unable to say. We know from the actual observations of the writers and by Mr. L. C. Bragg, that such a method of procedure is pursued by the elm woolly aphis, *Schizoneura americana.* The fall winged lice of this species that give birth to the sexual forms sometimes accumulate in thousands about the bases of elm trees to deposit the sexual forms, but we have been unable to discover such a habit for the woolly apple aphis. We are not averse to believing that it has such a habit, but we have not been able to discover it and do not feel sure that Prof. Theobald intended to announce that he had for this species.

During the winter of 1906-07, when the thermometer barely reached zero in the Grand Valley about Grand Junction, and only reached —9.3 degrees at Fort Collins, the lice lived over winter in large numbers upon the trunks and branches. As a result, in the Grand Valley especially, this louse was the most numerous the following spring and summer that we have ever known it in the state. Fortunately, the lady beetles (Plate II, Figs. 12, 13, 14, 15) aphis-lions (Plate I, Fig. 15), and syrphus larvae, came through in good condition, too, so that by the first of August scarcely any of these lice could be found anywhere in Colorado above ground.

Last winter (1907-8) the temperature went several degrees lower, and at Fort Collins there were several nights when the temperature went below zero, yet quite a number of the little, dark, over-winter form of this louse lived through in old scars and beneath the dead bodies of the lice of the previous fall.

How many of those that migrate upward from the crowns of the trees in the spring are really from the roots, and how many are the over-winter form from the tops that went down in the fall, it is impossible to state with certainty. Tanglefoot bands put about the trees early in the spring caught large numbers of the ascending lice at the lower margin and apparently the greater proportion, early in the season, were the over-winter form.

If the lice have lived over in any great numbers, a man with a good hand glass (which every fruit grower should have) can easily detect the fresh white secretion appearing in the old scars.

All the lice appearing upon the trees or roots during spring and summer are viviparous females. That is, they are lice that give birth to living young without the intervention of males. Probably these lice live about three weeks after becoming mature, during which time they will give birth to from 75 to 125 young. These young require about ten days to mature and, like the parent, give birth to their quota of young and die. This process continues generation after generation, all the lice being wingless and viviparous until about the first week in September, when in some of the colonies, winged viviparous females will begin to appear in small numbers. They soon leave the colonies and take wing, and to the present time we have entirely failed to determine what becomes of them. When inclosed by cheesecloth so they cannot escape, they persist in crawling about over the walls of their cage and never return to the tree. Before dying, they give birth to the true male and female lice, but this is either done upon the walls of the cage or upon the inclosed trees. They act like a fall migrant of a louse having an alternate food plant and possessed of an instinct to desert the old one. It is possible that the bad behavior of the lice has been due to the artificial conditions under which they have been studied. We believe Professor Alwood was the first to observe and describe the true male and female of this louse,* and his observations also were confined to the laboratory.

The winged viviparous females appearing in the fall give birth to from six to twelve young, about half of which are males and half females. These egg-laying females are yellowish brown in color and are about half as large as the common adult apterous females. The male is rather light yellow in color and is considerably smaller than the female, and neither grow after being born, having no mouth parts with which to take food. The female develops one large yellow egg that is fully two-thirds as long as her own body. The female is also wingless. Ten winged females were dissected and from them were obtained males and females, as follows:

* Bull. 102, Virginia Experiment Station, p. 139, and Spec. Bull. (C. P. C. No. 45), p. 12, of the same station, 1904.

MALE AND FEMALE BIRTH RECORD OF WINGED MIGRANTS

	MALES	FEMALES		MALES	FEMALES
Louse ----1	4	5	Louse ---9	2	4
" ----2	5	5	" ---10	4	5
" ----3	3	5	" ---11	3	6
" ----4	3	5	" ---12	4	5
" ----5	3	4	" ---13	4	5
" ----6	4	1	" ---14	3	4
" ----7	5	2	" ---15	4	5
" ----8	3	2	" ---16	4	3

In a state of nature these remarkable instincts and life habits were not developed without a very deep-seated cause. One purpose seems to be to enable the aphis to get away from its mortal foes and continue its existence. The lady beetles * and other predaceous enemies are likely to become so numerous late in the season as to exterminate the colonies of woolly aphis, but if such a thing should happen, the eggs deposited by the true females will start a number of new isolated colonies another spring away from the old haunts of the enemies, and in this manner greatly increase the probability of the continuation of the species. Probably another equally important consideration is the increase of food supply through the dissemination of the species.

When cold nights come on, about as winter apples are being picked, many of the young lice (Fig. 11) do not locate, take on a dusky to dark greenish color, do not grow or secrete any cotton or shed their skins, and seem to be developed for the special purpose of withstanding the winter's cold to start another round of woolly aphis life the next spring.

If a tree top is badly infested, these specialized young will crawl down the trunk in countless thousands in the fall. We have often seen them abundant enough to very perceptibly darken the trunk of the tree and the earth for some inches about the crown. Great numbers crawl into crevices in the earth, about the crowns of the trees, and others get into every possible hiding place beneath loose bark, in cavities of rotten limbs, in old scars and other places that will afford a little winter protection.

Apparently, all the lice in our Colorado climate that insert their beaks and begin taking nourishment in the fall are killed when severe freezing weather comes on. By far the greater num-

*We have found **Hippodamia convergens** to be by far the most abundant lady beetle attacking this louse. **Coccinella transversalis, C. transversoguttata,** and **C. monticola** we have also found feeding upon them to some extent.

ber of the over-winter lice perish, but a few find sufficient protection to enable them to withstand the cold and they start new colonies in the spring. Our tanglefoot bands have caught large numbers of these lice upon the lower half in the spring, and enormous numbers in the upper half in the fall.

PARTS OF TREE MOST ATTACKED.

A great deal of digging about the trees in orchards of the Western slope proved that very little harm is done to roots that are more than 10 inches below the surface of the soil, and more than three feet from the crown of the tree. If water sprouts are allowed to grow up about a tree, they are almost sure to be very lousy, especially just at the ground.

Succulent and rapidly-growing parts, especially grafts, are very susceptible to attack.

Of all the varieties grown in Colorado, the Missouri Pippin seems to be worst infested, and Northern Spy is practically exempt. We have yet to find a single tree of this latter variety much infested. In a few instances slight infestation has been found in pears.

Loose, porous soils seem more favorable for the development of this louse upon the roots than are the heavier and more compact soils.

INJURIES.

The woolly aphis belongs to a gall-producing group of plant lice. Their punctures in the bark have an irritating or poisoning effect, which results in an increased flow of sap, which is to the advantage of the louse, and at the same time it causes an abnormal growth of the part. Very small rootlets may have lumpy galls of considerable size (Plate III, Fig. 4), and larger roots may have an aggregation of these swellings involving a large portion of the root surface. As a result of these attacks, the roots often die and rot and sometimes the condition is so bad that a tree may be pushed or blown over because of the number of roots that have died near the crown of the tree. When the lice attack the tender bark about a scar, upon trunk or limb, the new growth is made more or less gnarly, but the effect is not so pronounced as upon the roots. The lice also attack the tender bark of the small limbs, and particularly where rapid growth is taking place, so that grafts and water sprouts are usually worse infested than other portions of the tree. Upon these rapidly growing parts the lumpy growths often become very numerous. The galls are usually smooth but often crack open, and especially is this true in cases of severe infestation.

If this louse is very abundant, either upon roots or limbs, the result is an unthrifty tree, bearing small and poorly colored fruit. Even if the fruit is worth picking it will be more or less smeared with the excretions of the lice, and the pickers may have their clothing almost completely colored with the red juices of the crushed lice.

Probably the injuries to the tree are greatest from the root attack, but the direct losses to the orchardist are doubtless greatest from the injuries to branches and fruit.

PREVENTION.

Prevention is usually much better than any remedy, but we are seldom aroused into action until we are hurt, and money spent on preventive measures is likely to be considered money thrown away. The greatest care should be exercised to avoid setting young trees with woolly aphis already upon them. Such trees have a severe handicap from the first. To avoid this handicap purchase trees, so far as possible, from nurseries that send out clean stock and then insist on your nursery stock being thoroughly inspected by a competent person and, if infected, either reject it or insist upon thorough disinfection.

One way to prevent the root injuries of this louse is to plant only such apple trees as are grown upon Northern Spy roots.

If nursery stock is received with the roots "puddled," covered with mud, insist upon the mud being thoroughly washed off so as to expose the roots for inspection. This is one way nurserymen have of covering up the woolly aphis on the roots.

As we find that the lice seldom are found upon roots more than ten inches from the surface of the ground, this is a strong hint that the soil for a successful apple orchard should be deep, and that planting, cultivation, and irrigation should be so managed as to make the trees deep rooted. Set the trees rather deep, irrigate thoroughly but not often, and cultivate deeply, from the first, between the rows.

Finally, during the last half of August, before the winged lice appear, thoroughly spray for the purpose of cleaning up the lice upon the tree tops, so that the winged migrating form can not spread about to distribute the species to other trees.

NATURAL ENEMIES.

Notwithstanding the fact that this louse is heavily covered with a protective waxy secretion, it is freely preyed upon by lady-beetles (*Coccinellidae*), Syrphus flies, and Chrysopa larvae, commonly called aphis-lions or lace-wing flies. The orchardist will often notice that certain limbs or trees that were badly infested early in July may be nearly or quite freed from the lice by the

middle of August. We had an excellent illustration of what the predaceous insects can do in this way last year. Probably this insect never was so abundant in the orchards of the state as they were last year, from their first appearance in the spring until about the middle of July. About that time the enemies had become so abundant that a noticeable decrease soon became apparent and by the 10th of August it was almost impossible to find a living louse above ground. Upon the roots there was no noticeable change in the infestation. The enemies then left the trees, and the few lice that were overlooked. with a few others that migrated upward from the roots, soon began to increase in numbers, so that by the last of September the trees were showing a light infestation again. Apparently this is all easily explained. The winter of 1906-7 was very open and mild, so that plant lice of all kinds lived through unusually well and were very abundant early in the spring. As a result, there was a very abundant food supply for their enemies, which also increased with great rapidity, so that by the first of August they began to get the upper hand of the lice, and to prevent their own starvation, almost completely ate the latter from every exposed place. In the Grand Valley the greater portion of this benefit was done by the lace-winged fly (Plate I, Fig. 15), while upon the Eastern slope the lady-bettles (Plate II, Figs. 12, 13, 14, 15) were the chief benefactors, with the lace-winged flies and the Syrphus flies as efficient helpers in the good work. Specimens of a small black parasitic fly* were taken by Mr. L. C. Bragg, ovipositing in this louse at Fort Collins, August 20, 1908.

REMEDIES ABOVE GROUND.

Wherever this louse can be reached by sprays, it may be destroyed, like any other plant louse, but one important precaution is necessary, the spray must be applied with sufficient force to wet through or remove the woolly covering. This louse is then more easily killed than is the green apple aphis, which curls the leaves for protection.

There are several spray materials that may be used with success. In fact, any spray that is generally successful when used for the destruction of plant lice may be considered useful for the destruction of this insect.

KEROSENE EMULSION.

When properly made, a good kerosene emulsion has no superior, as a spray for the destruction of the woolly aphis, so far as we have been able to determine, and it penetrates the woolly covering better than most insecticides. When used in the usual strength of 1-15 (7 per cent.) oil we have always found it to be suffi-

*Aphelinus mali (Hald.), determined for us by Dr. L. O. Howard.

ciently strong. A preparation of 1-20 (5 per cent.) oil is usually successful if thoroughly applied and makes a spray of very moderate cost. Directions for the preparation of kerosene emulsion are given near the end of the bulletin. The trouble, if any, will be in obtaining a good emulsion from which the oil will not separate and collect upon the surface. To be successful use a moderately coarse and forceful spray. While we are inclined to consider a good kerosene emulsion the most efficient of all the insecticides we have used against the woolly aphis, we are aware that most orchardists have had so much trouble making it that they prefer to use something more easily prepared, even at a somewhat increased expense. Such men as B. A. Smith, F. C. Jaquette, Joseph Cornetto, E. M. Cheedle, W. K. Haines, and others in the Grand Valley, have used the emulsion with the best of results.

SCALECIDE AND OTHER MISCIBLE OILS.

There are upon the market a number of so-called miscible, or soluble, oils which, when put into water, break up into very fine particles and form a milky white emulsion. These, like kerosene emulsion, make a very good and efficient spray for lice if they do not separate to form a film of pure oil on top. The only preparation of this kind that we have used at all extensively is Scalecide. When used as strong as 3 to 4 per cent. oil we have found it very effectual. Apparently the soluble oils have to be used with more care than kerosene emulsion on account of their liability to injure foliage when too strong.

SOAPS.

In our experiments for several years past some of the standard whale-oil or tree soaps have given very satisfactory results, but, for some reason, the orchardists have not seemed to be as successful with the soaps they have used. We have used chiefly the brands sold as Good's Whale-oil soap, and Bowker's Tree-Soap, and 1 pound to 8 gallons of water has usually been sufficiently strong. The warmer these soaps can be when applied, the better. We believe the soaps can be purchased so as to be among the cheapest of spray materials, and if anyone has been using a brand that has given him success, we see no reason why he should make a change. Mr. A. L. Roberts, of Paonia, reported to us last year that he completely cleaned the woolly and green apple lice out of his orchard by thoroughly spraying with 13 pounds of whale-oil soap and 1 gallon of Black Leaf to each tank of 220 gallons of water.

"BLACK LEAF."

The Kentucky Tobacco Product Company, of Louisville, Kentucky, manufactures a tobacco extract which they sell under the

above trade name and which has become very popular among the orchardists of Delta County as a spray for all plant lice in their orchards. Purchased in car load lots, it is one of the cheapest, and most easily prepared, of all spray materials used, and has given remarkable satisfaction, and in our experiments it has given splendid results. Aside from the fact that it does not penetrate the woolly covering of the lice quite so readily as the kerosene emulsion, we are inclined to place it about on a par with that insecticide in its killing effects. When this, or any other spray, is used, special care must be taken to throw the spray from all directions and under high pressure, 140 to 180 pounds, if possible, to get best results. The manufacturers write us that they take great pains to put out a uniform product of Black Leaf so far as the nicotine content is concerned, and that this is the only ingredient that it contains that has any special insecticidal value. This being the case, if the manufacturers keep up the present standard of quality in this dip, we predict that it will come into very general use for the destruction of all aphids upon out-of-door plants.

While the orchardists have been using Black Leaf, in most cases, in the proportion of 1 gallon to 65 gallons of water, we have found in our experiments, where we know that thorough treatments have been made, that 1 gallon to 75 gallons of the watery mixture is very uniformly successful in killing all the lice, and 1 to 100 (a 1 per cent. mixture) seldom fails to give excellent results.

It is a good plan for the orchardist to treat a few trees with varying strengths of his mixture a day or two before taking up his spraying in an extensive way, and note carefully the results. In this way he may save many dollars, either from using the insecticide in strengths that are unnecessarily strong, or by throwing away a large amount of time and material in the application of a spray that is too weak to give satisfactory results.

TOBACCO DECOCTIONS.

Some may prefer to make their own tobacco sprays, either by using tobacco stems, tobacco dust, or whole-leaf tobacco. While fruit growers do not report very uniform results from their own tobacco preparations, our experience has been different. When we have steeped tobacco stems, or tobacco dust, in water in the proportion of 1 pound to two gallons, or the whole-leaf tobacco in the proportion of a pound to four gallons of water, we have been very uniformly successful in getting a decoction that would kill the lice. See directions for preparing tobacco decoction near the end of this bulletin.

Mr. W. S. Coburn, President of the Colorado State Board of

Horticulture, tells us that he has had excellent success by using tobacco of his own raising in the proportion of 1 pound to 6 gallons of water after steeping for a full hour and then applying warm.

LIME-SULFUR SPRAYS.

Lime-sulfur sprays used during the summer, when the lice have a wooly covering, have not proven satisfactory in our experience. For early spring spraying, see below.

Chloroleum, potash lye, and strong lime washes have also been tried without marked beneficial results.

LATE WINTER OR EARLY SPRING APPLICATIONS.

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

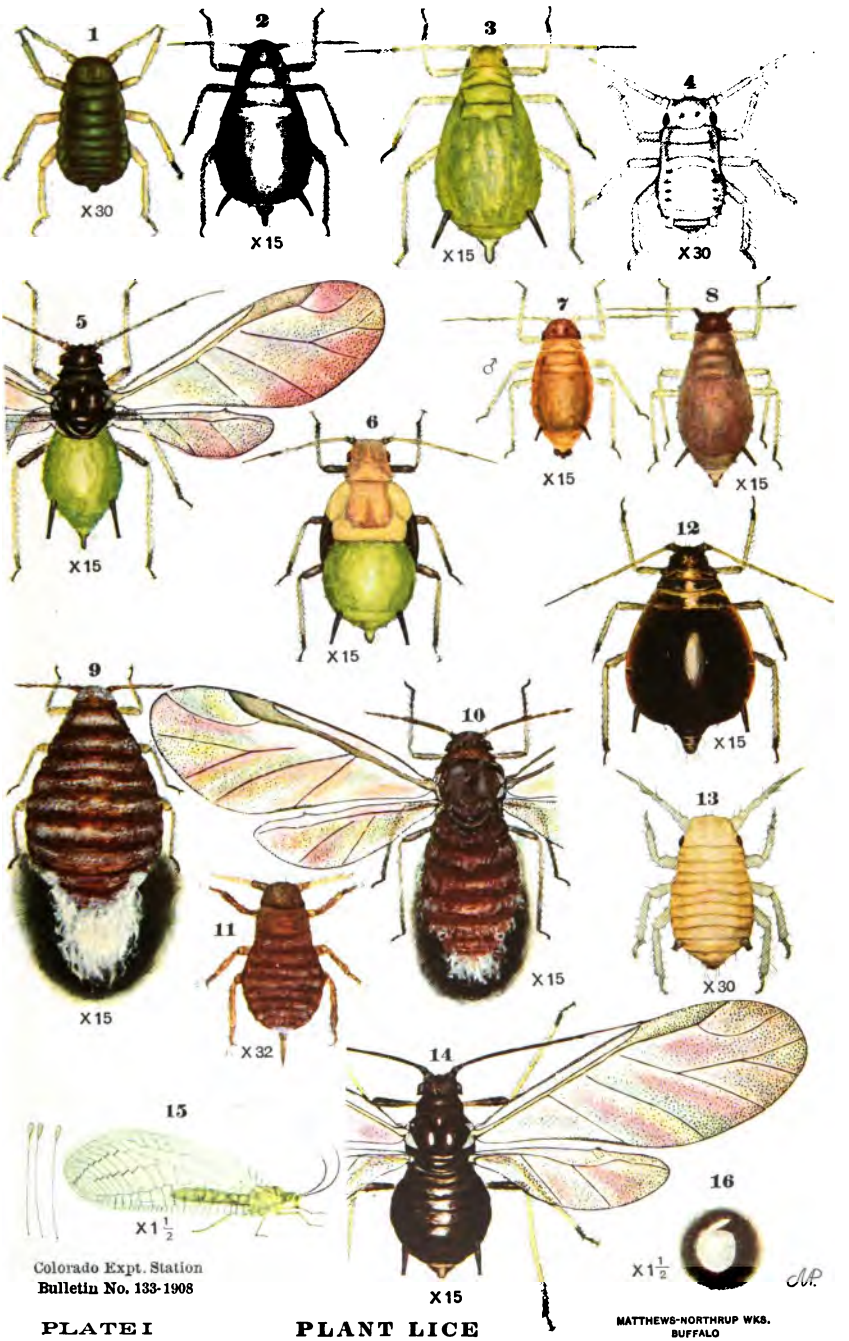
Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphis were partially freed from the woolly aphis also.

We have no doubt but what kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps, could be used successfully as early spring sprays for the destruction of the overwinter lice upon the tree top, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphis, and as the orchardist is likely to want to destroy both of these lice at the same time, if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the woolly aphis the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then, as a final act for best results, put tanglefoot bands about the trunks of the trees so that the lice at the roots cannot migrate to the top. For the application of these bands, see next paragraph.

TANGLEFOOT BANDS.

In the experiments upon the Western slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan, and is



Colorado Expt. Station
Bulletin No. 133-1908

PLATE I

PLANT LICE

MATTHEWS-NORTHRUP WKS.
BUFFALO

LIBRARY OF THE UNIVERSITY OF

similar to the sticky material put upon the Tanglefoot Fly-paper. When at all abundant upon the trees, the newly-born lice are much inclined to travel about, and it is often astonishing to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Mr. Weldon, field entomologist, reports these bands doing harm to trees, where they have been on for more than a year. The Tanglefoot was placed directly upon the bark, but it would be safer to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band, in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphis.

MOUNDING AND CULTIVATING.

The woolly aphis is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree, but they get down to them directly from the surface above. So far as possible, the descending overwinter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration, both to and from the roots, can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compacted after a rain or an irrigation.

TRIMMING.

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths, and a thorough thinning of the top so that plenty of sunlight can enter, has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

TREATMENT BELOW GROUND.

The treatment below ground is all aimed at the lice that are

within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below, if they can only be put in contact with the lice. The orchardist should be cautious, also, not to accumulate in the soil, about the crowns of his trees, substances that are likely, either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY.

For many years tobacco, in the form of dry dust, stems or leaves, has been considered the best known remedy for this louse. Soapy solutions have also been thought of some value. In Bulletin 23 of the Georgia Experiment Station (1907), Professor R. I. Smith, reports far better success with kerosene emulsions than with tobacco or soaps for the destruction of the apple woolly aphis upon roots.

A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given in the table on the following page.

The authors are under special obligations to the men who kindly offered their trees for the experiments and in other ways aided in carrying on the work.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following. The materials used upon the roots were kerosene emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, Adams' lime-sulfur, whale-oil soap, and carbon bisulfide, as shown in the table. Other tests were also made upon the roots which are not scheduled.

Before making the applications, the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins, which varied some in depth and diameter, with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. Both the treated trees and the checks were given a rating of 1 to 4 as to degree of infestation, so as to be able to make fair comparisons in determining results. The liquid applications were then forcefully sprayed upon the roots in these basins until two or three gallons had been applied, and when the liquid had nearly or quite soaked into the

EXPERIMENTS FOR THE DESTRUCTION OF THE WOOLY APPLE APHIS

ORCHARD OF	INSECTICIDES	STRENGTH	TREATED	DATE USED	EXAMINED
L. P. Nissen	Lime and Sulfur	15, 15, 50	Tops and Roots	November 7, 1906	Nov. 19, '06
	Chloroleum	1 to 40	Tops		Nov. 23, '06
	"	1 to 50	Tops and Roots		Nov. 28, '06
	Scalecide	5% oil	" "		Jan. 11, '07
	Tobacco Dust	2, 4, 5, 6 and 8 lbs.	Roots	Nov. 23-28, 1906	Mar. 15, '07
	Tobacco Stems	2, 4, 5, 6 and 8 lbs.	"		Mar. 25, '07
	Quick Lime	10 and 20 lbs.	"		June 6,07
	Rex	1 to 11	Tops	Mar. 25, '07	
	Ker. Emulsion	7% oil	As Bands		
	Tanglefoot				
H. D. Smith	Ker. Emulsion	22.2% oil	Tops	December 18, 1906	Summer, '06
	" "	16.6% oil	"		Jan. '07
	" "	13.3% oil	"		
	Scalecide	1 to 19 (5%)	"		
	Tanglefoot			June as bands	
R. E. Turpen	Rex L. S.	1 to 8 with lime	Tops	March 2-22, 1907	April 26 1907
	Adams L. S.	" "	"		
	"	1 to 8 with no lime	"		
	Lime and Sulfur	1—1—2	"		
	" "	1—1—3	"		
	" "	1—1—4	"		
E. M. Cheedle	Rex L. S.	1 to 8 no lime	Tops	March, 1907	June 5, '07
	Tobacco stem Decoction	1 lb. to 1 gal.	"	Apr. 2-6, '07	Aug. 22, '07
					June 5, '07
	Ker. Emulsion	7% oil	"	Mar. 1 to Apr. 6	Aug. 22. '07
F. C. Jaquette	Whale-oil Soap	1 lb.—4 gal.	Tops	April 2	
	Ker. Emulsion	9.4% oil	"	April 2	
	Ker. Emulsion	6% oil	Roots and Tops	April 9	April 9 to June 7
	Ker. Emulsion	6% oil	Roots	June 7	June 20
	Checks				
	Carbon Bisulfid	3 oz. to tree	"	April 11	May 16
B. A. Smith	Lime Sulfur, Rex & Adams		Tops		
	Tobacco Dust Decoction	1 lb.—2 gall.	"		
	Tobacco Dust Decoction	1 lb.—3 gall.	"		
	Ker. Emulsion	5% oil	"	Mar. 2 to 6	Mar. & May
	" "	6% oil	"	Mar. 2 to 6	" "
	" "	7% oil	"	May	
J. Cornetto	Ker. Emulsion	3, 5, 6, 7, 10, 15 20, 33, and 50% oil	Roots	June 26 to July 2	July 22
	" "	5 and 6% oil	Tops		August 22 and Sept. 13
	Black Leaf	1 to 50	Roots		
	" "	1 to 66	"		
	" "	1 to 75	"		
	Tobacco Dust	1 lb. to 1 gal., 1 lb. to 3 gal., 1 lb. to 5	"		
	Tobacco Stems	2 lbs.—1 gal.	Roots		
	" "	1 lb.—1 gal.			
	" "	1 lb.—3 gal.			
	" "	1 lb.—5 gal.			
	Tobacco Stems	6 lbs. per tree	Roots		
	Scalecide	1—40, 1—60, 1—50	Roots		

ground, the basin was filled again and the earth banked well about the trees. In hard, compact soils it is best to irrigate a few days prior to making the treatment so as to loosen the soil and lessen the labor of excavating about the trees.

Summing up the results to September, 1907, it may be said, that practically all strengths of kerosene emulsion (3 per cent. to 50 per cent.), killed the lice well when the roots had been well treated. Where less than 6 per cent. of oil was used, the odor of kerosene soon disappeared and reinfestation soon took place by the lice that migrated downward from the top. Where 7, 10 or 15 per cent. of oil was used, the effect was still more lasting, and the 20, 33 and 50 per cent. treatments gave practically perfect freedom from lice about the crown and roots throughout the season.

The trees in the above experiment were examined later by Mr. George P. Weldon, who reported upon the effects of the various applications, as follows:

EXPERIMENTS IN THE ORCHARD OF J. CORNETTO.

"Grand Junction, Colorado, July 10-11, '08.

"I am disappointed to find that the wooly aphis is very abundant on all of the roots of treated, as well as check trees, in the experiment, even where a 50 per cent. kerosene emulsion was used. Where this strength was applied, the odor of the soil is still very pronounced when then earth is stirred, and the trees show severe injury from the application. The roots are being killed and the leaves are wilting, and it is probable that the trees will soon die. A comparison of the treated trees with the check tress does not indicate that any benefit from the various treatments has continued to the present time. Even where the 50 per cent. oil was used, the lice are as abundant as upon the check trees in the experiment. There are almost no lice above ground upon any of the trees at this time. With the exception of the 50 per cent. kerosene emulsion treatment, none of the applications seem to have done any harm to the trees.

"Roots treated with tobacco dust, even where eight pounds to a tree are used, do not show any indications of benefit from the application now.

"In the Jacquette orchard I find that the Tanglefoot bands that have been on for two seasons are doing serious injury to the bark of the trees, especially upon the south side."

Some orchardists have reported to us that they believe they have had trees sickened and even killed from the kerosene emulsion that accumulated about the roots at spraying time, and one or two have reported applying kerosene emulsion to the roots of apple trees during the winter for the destruction of the woolly aphis and that the trees all died after a few years. So, while we know that kerosene emulsion is a very effectual destroying agent for woolly aphis on roots, we are inclined to advise those who use it to be cautious and to keep a close watch of their trees and stop farther treatments as soon as any signs of injury appear. It might be well to select a few trees that one does not care very much for and

treat them somewhat severely with the thought that so long as they show no injury, it is probably safe to treat others more lightly.

CARBON BISULFID.

This insecticide has often been reported successful against this insect upon the roots.

A splendid opportunity was afforded to observe its results in the 20-acre orchard of Mr. F. D. Barney, where about 200 pounds of the liquid was used on 12-year-old apple trees. The treatment was begun on April 11, 1907, and was continued several weeks before being completed.

At the beginning of the treatment a trench 4 or 5 inches deep was dug encircling the tree and about 3 to 4 feet in diamater. Three ounces of liquid carbon bisulfid were poured into the bottom of the trench, and moist earth thrown quickly in and packed down with the shovel. This method did not seem successful, and another process was substituted. A shovel was thrust deeply into the ground about 18 in. to 2 ft. from the base of the tree with the blade broadside to the tree. The handle was then tipped forward and the carbon bisulfid poured in at the center of the opening at the back of the shovel. The shovel was then withdrawn and the earth packed upon the spot treated. Care was taken not to pour the liquid directly upon the roots. From three to six holes were treated in this way about each tree and about three ounces of the liquid used. At this rate the cost of the material did not amount to as much as 3 cents per tree.

Observations on May 16th showed some good accomplished, especially where the infested roots had been near to the points where the bisulfid had been poured, but there were many living lice still remaining about the crowns of the trees. The soil at time of treatment was loose, friable and moist, but not wet. The results seemed to indicate that such a treatment would be profitable in cases of severe root infestation, but not as effective as kerosene emulsions or tobacco decoction applied directly to the exposed tree roots.

Tobacco Dust and Stems have not given very satisfactory results in our experiments nor with most of the orchardists who have tried them. Where 5 or 6 pounds to a tree has been used directly upon the exposed roots and about the crown, followed by a thorough irrigation about the trees, we have had reports of good and poor results, even when thoroughly irrigated at once to soak the juice down about the roots, so we do not think tobacco dust or stems can be relied upon for satisfactory results.

Tobacco Decoctions in which 2 pounds of stems, or dust, or 1 pound of whole leaf tobacco was used to each 3 gallons of water and

forcefully sprayed upon the exposed roots gave fairly good results, but these were not equal in their killing and repelling effects to a 10 or 15 per cent kerosene emulsion.

Black Leaf Dip used in the proportion of 1 gallon in 65 gallons of water gave results similar to the preceding.

Scalecide used 1 to 40, 1 to 50 and 1 to 60 in water killed the lice fairly well, but had very little repelling effect afterwards.

Soaps used for root treatment were of doubtful benefit.

Some Wholly Unsuccessful Substances were "Chloroleum," lump lime (10 to 20 pounds to a tree), potash lye, wood ashes, salt and flooding with water for several hours.

ROOT TREATMENT OF NURSERY STOCK

Apparently none of the inspection laws have prevented, though they have greatly lessened, the shipment of trees infested with woolly aphis. It is commonly recommended to dip or fumigate such trees to destroy the lice.

We have found the ordinary dipping process quite ineffectual in cases of severe infestations on account of the protection afforded by the woolly secretions, but we have had perfect success by untying the bundles and forcefully spraying the trees upon roots and tops with kerosene emulsion (7 to 10 per cent oil), or one of the tobacco or soap preparations used for top treatment. *Make the spray forceful and drench all parts.* It requires but little time or material to treat thousands of trees. Where this work is to be done on a large scale, a water tight spraying surface or pan could easily be arranged with a drainage tank so that the same spray material could be used over and over.

Dipping for 6 seconds in water heated to 140 degrees Far., and fumigating for 40 minutes in hydrocyanic acid gas we have also found efficient remedies for the destruction of this louse on nursery trees.

CONCLUSIONS AS TO BEST METHODS OF TREATMENT

Just before the buds open in the spring, spray very thoroughly with a 7 per cent kerosene emulsion, Black Leaf dip 1 pound to 60 gallons of water (or some other strong tobacco decoction), or a good whale-oil soap, 1 pound to 6 gallons of water. Spray the entire trunk and also the ground about the crown of the tree. Immediately after treatment apply a Tanglefoot band over cotton so as to prevent the upward migration. If the lice become very numerous at any time upon the tops, spray them forcefully with the 7 per cent emulsion, or Black Leaf, 1 part in 70 parts of water.

Root treatments are temporary in their effects. When the roots become very badly infested, treat as above described with 10 per cent kerosene emulsion, Black Leaf dip (1 to 50), 2 to 3 gal-

lons to a tree, or, if the soil is quite open and porous, carbon bisulfid*.

THE GREEN APPLE APHIS

(*Aphis pomi DeGeer.*)

Plate I, Figs. 1 to 8, and Plate III, Fig. 5.

This insect was first described in Europe by DeGeer in 1773 and two years later was described by Fabrecius as *Aphis mali.* It is not known when it first appeared in America, but Mr. Theodore Pergande has been quoted as saying that he first saw it here in 1897. In 1900 Dr. J. B. Smith gave excellent descriptions of this louse in its different forms with an account of its habits in Bull. 143 of the New Jersey Experiment Station. This seems to be the first published account of what we are calling the "green apple aphis" in this country. Now it is known to be very generally distributed throughout the country, being readily carried upon nursery stock in the egg stage.

The dry climate of Colorado seems favorable for the development of this louse and its natural enemies have not been sufficient in recent years to keep it in check without the aid of spray pumps and insecticides.

Sanderson's statement* that *A. pomi*, "is, however, by no means as common as *A. fitchii*" (really *avenae*), surely does not apply at all to Colorado, where the latter species, in all the apple growing sections, is a comparatively rare insect and one that we have never found occuring in abundance upon a single tree. *A. pomi* is one of our very worst orchard enemies, and is, also, the species most commonly brought into the state in the egg stage, upon nursery stock.

FOOD PLANTS

This louse spends its entire life cycle upon the apple and pear trees and does not, so far as we have been able to observe, leave these trees during a portion of the summer to feed upon other plants, as so often occurs with other species. So one need never fear that this insect will migrate from the apple and pear trees to other fruits or vegetables, and it is equally true that it will not migrate to the apple and pear trees from weeds or vegetables, as it does not infest them.

Besides the apple and pear, this aphis also attacks the hawthorn, the quince and the flowering crab, but the cultivated apple seems to be its favorite food plant. Among the apple trees it has its preference. The Missouri Pippin seems to be its first choice

* Carbon bisulfid may be procured in quantity from Edward R. Taylor, Penn Yan, New York.

* Thirteenth Ann. Rep. Del. Ex. Sta., p. 131, 1901.

while Rome Beauty, Black Twig, Ben Davis and a few others are close seconds, and the Northern Spy is scarcely attacked at all.

This insect gets its food by inserting its beak and sucking the sap from either the leaves or the rapidly growing, softer and more tender twigs. For this reason rapidly growing young trees, grarts, and water sprouts are worst infested. When upon the foliage, this louse feeds, for the most part, upon the under side of the leaves, which curl in such a way as to give it considerable protection from the direct rays of the sun, and from sprays that are not used with force and thoroughness.

LIFE HISTORY

Like most insects, this green aphis has very definite life habits. Probably we cannot do better than to begin with the egg and follow it through its different stages of development.

THE EGGS

The winter is past entirely in the egg stage upon the twigs of the trees that were infested the previous fall.

Many lice select the axils of buds and rough places in the bark for the deposition of their eggs, but this one seems to prefer the free surface of the rapidly growing shoots. When the lice are abundant, the water sprouts, in particular, are often fairly blackened with eggs (see Plate III, Figure 5).

When first deposited, the eggs are light green in color, but soon become shining black from the action of the sunlight upon them. They are long oval in shape and are just large enough to be plainly seen by one who has good eye sight. By actual measurement it would require 40 of these eggs, placed end to end, to extend one inch.

Very few of the eggs ever hatch, according to our observations. On the eastern slope, at least, it seems doubtful if more than one per cent hatch in average years. Even this small percentage of the eggs hatching is sufficient with the rapid rate of increase to enable this insect to become destructively abundant before fall. When the time arrives for the little louse to come from its winter quarters, the shell splits longitudinally upon the upper surface near one end and the prisoner, with much writhing and kicking works itself out. No definite date can be fixed for the hatching. The first lice were found emerging in 1907 at Palisades just as the first apricot blossoms were opening. At that time the apple blossoms were but little swollen. In a general way it may be said that the lice begin to hatch a little before the apple buds show any green and continue to hatch for two or three weeks, depending upon whether the weather is warm or cold most of the time.

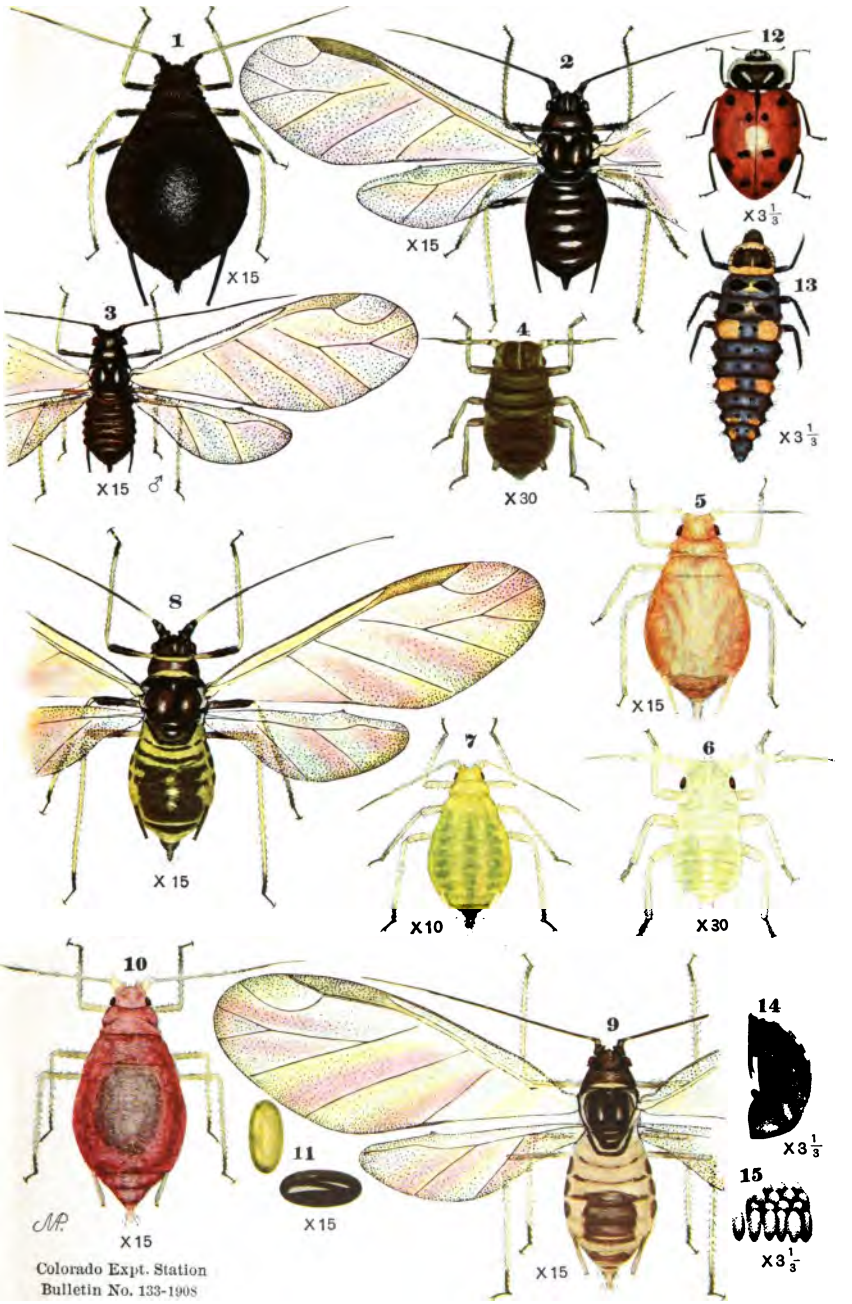


PLATE II

PLANT LICE

M.·N. WORKS
BUFFALO

LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

THE STEM MOTHERS

Plate I, Figs. 1 and 2.

The lice hatching from the eggs in the spring are all females, and are called "stem mothers" because from them spring all the succeeding brood of the year. No other lice of the year are quite like these that come from the eggs. The little louse upon first hatching is very dark green in color while other young of the year are very light yellowish green (Plate 1, Figs. 1 and 4). If the buds are not yet open, the stem mothers are able to live a few days for the buds to swell enough to enable them to insert their beaks into the tender tissue of the young leaves for their first meal. As soon as the buds open enough to make it possible, the little lice work their way down into the folds of the opening leaves where they are protected from the cold and from the lady beetles and other insect enemies and the death dealing sprays of the orchardist. In about two or three weeks, if the weather is warm, our stem-mother will have attained full development and will begin to give birth to living young at the rate of 3 or 4, to 10 or 12 a day. During their whole life these stem-mothers differ in appearance from any of the later broods of the year. They never get wings, are of a rather dark green color with a conspicuously dark colored head; the antennae are shorter and usually six, though they may be seven jointed; the cornicles are rather short and black and the cauda or tail is also black. The stem-mother is usually a little smaller than her grown children and grand children, measuring only .06 of an inch (1.50 mm.) in length when fully grown. (See Plate I, Fig. 2.)

SECOND GENERATION

As soon as the stem mother becomes fully grown, she begins to give birth to living young which constitute the second generation. Each female may deposit as many as 75 to 100 young during a period of two or three weeks and then she dies. These young are all female which, like their parent, are capable of giving birth to living young. We have found a very small percentage of the second generation getting wings. So the winged lice may begin to scatter from tree to tree and orchard to orchard at Grand Junction about May 10th, and at Fort Collins about June 1st. It is not until the 3rd. generation that the winged lice appear in large numbers, so that the migration of winged lice is not usually noticed until about the first week in June in the warmer orchard sections in Colorado, and two or three weeks later in the colder portions. After mid summer the winged lice begin to grow fewer in numbers and disappear entirely about September 1st.

WINGLESS FEMALE OF SUMMER GENERATIONS

Plate I, Fig. 3.

The summer wingless females (all after the stem mother) when fully grown, are a trifle larger than the first generation, are yellowish green in color, have 7 joints to the antennae, both antennae and cornicles are longer than in the stem mother, and the cornicles, cauda and the greater portion of the antennae are black. These females continue until late fall and are very prolific, giving birth to living young.

WINGED FEMALES

Plate I, Fig. 5.

The winged females also give birth to living young lice. They fly about to other trees and so establish many new colonies, some of which will be likely for a time to escape being found by their enemies.

These winged migrants are not numerous until the third brood and they continue to appear in considerable numbers until about the last of August, when they soon disappear, and true sexual males and egg-laying females take their places.

About the first of September* males and egg-laying females begin to appear. The males and females pair and the latter begin to lay eggs about the middle of September and continue to do so until killed by severe freezes.

MALES

Plate I, Fig. 7.

The male is wingless, is yellowish or rusty brown in color, and is much smaller than any other adult lice of the year.

EGG-LAYING FEMALE

Plate I, Fig. 8.

The egg-laying female is considerably larger than the male, but is smaller than the other female lice of the year and is yellowish green in general color with considerable variation.

NATURAL ENEMIES

This louse is attacked by about the same natural enemies as the wooll aphis. The Lady Beetles seem to us to be the most efficient as destroyers of it though the syrphus flies and aphis lions (lace-wing flies) also kill great numbers. They are almost never attacked by parasites, in fact the only parasitic attacks that we have seen have been by a minute Chalcid (*Alphalinus mali*)* that causes the lice to change to a deep coal black while they retain their natural size and shape.

* Our earliest date for males at Fort Collins is September 4.
* Determined for me by Dr. L. O. Howard.

Sometimes the orchardist thinks that ants are destroying the lice upon his trees. This is never the case. The ants visit the lice for their sweet secretions and are careful not to harm them and they ever stand ready to drive away many of the enemies of the lice.

REMEDIES

The remedies to use against this insect, from the time the buds open in the spring until the leaves drop in the fall, are the same as those given for the woolly aphis above ground. Kerosene emulsions that is one-fifteenth oil and Black Leaf dip, 1 part in 70 parts of water, are the two most favored sprays at the preent time in Colorado.

WINTER AND EARLY SPRING SPRAYS

For several reasons, late winter and early spring are most favorable for the destruction of the green apple aphis. The orchardist usually has more time then in which to do the work; the foliage being off, it requires less pains, time and material to make a thorough treatment, and by spraying early one avoids destroying the plant louse enemies which are killed along with the lice in summer spraying. If the work is well done in early spring, the trees should be free from lice until the winged migrants have flown in from neighboring orchards and established their colonies upon the trees. Such orchards will seldom become seriously infested before July, if they are at all during the summer, so they are sure to make their growth unhindered and will seldom fail to mature their crop in good condition.

Professor Aldrich seems to have been the first to report success from winter treatment of orchards for the destruction of the eggs of plant lice.* He reported very satisfactory results from the use of lime-sulfur sprays made by both the 1-1-2 and the 1-1-4 formulas (1 lb. lime, 1 lb. sulfur, and 2 gallons water; and 1 lb. lime, 1 lb. sulfur and 4 gallons water), but did not succeed in destroying the eggs with emulsions of kerosene oil.

In our experiments for the destruction of eggs we have found the oil emulsions useless, killing only in very high strengths, if at all.

The treatments that we have found quite successful for the destruction of eggs are:

Lime-Sulfur mixture, 1-1-2 formula, sp. grav. 1065.
Lime-Sulfur mixture, 1-1-3 formula, sp. grav. 1045.
Rex Lime-Sulfur, 1-8 strength, sp. grav. 1055.
Rex Lime-Sulfur, 1-4 strength, sp. grav. 1080.
Black Leaf, 4 per cent strength.

* Bull. 40, Idaho Exp. Sta., 1904.

Black Leaf, 3 per cent strength.
Black Leaf, 2 1-2 per cent strength (a little weak.)

THE CLOVER APHIS

(*Aphis bakeri* Cowen)

Plate III, Figs. 1, 2.

This louse was described by Mr. Cowen in Bull. 31 of this station in 1895. *Aphis cephalicola* Cowen, described from heads of white clover, is the same species.

On April 13, of this year we found a red stem-mother of some unknwn aphis rather common, and in many cases fully grown, upon the buds of apple and pear trees about Delta, Colorado. The color varied from a dark green streaked and mottled with red to a deep dark red, with cornicles very short and pale yellow throughout. At this time the apple buds were just beginning to open and peach trees were nearly in full bloom. It seems probable that these stem-mothers must have hatched fully two weeks prior to this date to have become fully grown. The green apple aphis (*A. pomi*) at this time was just hatching and none were found that were more than half grown.

The identity of the louse was not suspected until the department artist, Miss M. A. Palmer, suggested that the second brood lice looked like her drawings of the clover louse, *A. bakeri.* A careful comparison indicated that the two forms were identical except for a little difference in color. This second generation (the offspring of the stem mothers) were light green or yellowish green in color, while *bakeri,* upon clover, is pink or yellowish. A large pale orange blotch surrounding each cornicle is also quite characteristic. Sprigs of apple infested with this louse were put in a cage with red clover and the lice in all stages readily adopted the clover as their food plant. Later the pink form was also found upon apple and crabapple (*Crategus sp.*) and no doubt was left that all were one species with varations in color.

FOOD PLANTS AND LIFE HISTORY

Summing up the life habits of this insect from all the observations we have upon it in the records of the Experiment Station for the past nine years we conclude as follows:

The clover aphis, *A. bakeri,* infests the cultivated and sweet clovers and alfalfa throughout the warmer part of the year where, apparently, it never occurs in the oviparious form nor as eggs. In the fall, a portion of the winged lice migrate to apple and pear trees where eggs* are deposited to live over winter and hatch into the red stem mothers the following spring. The descendants of

* Oviparous females and eggs we have not seen with certainty.

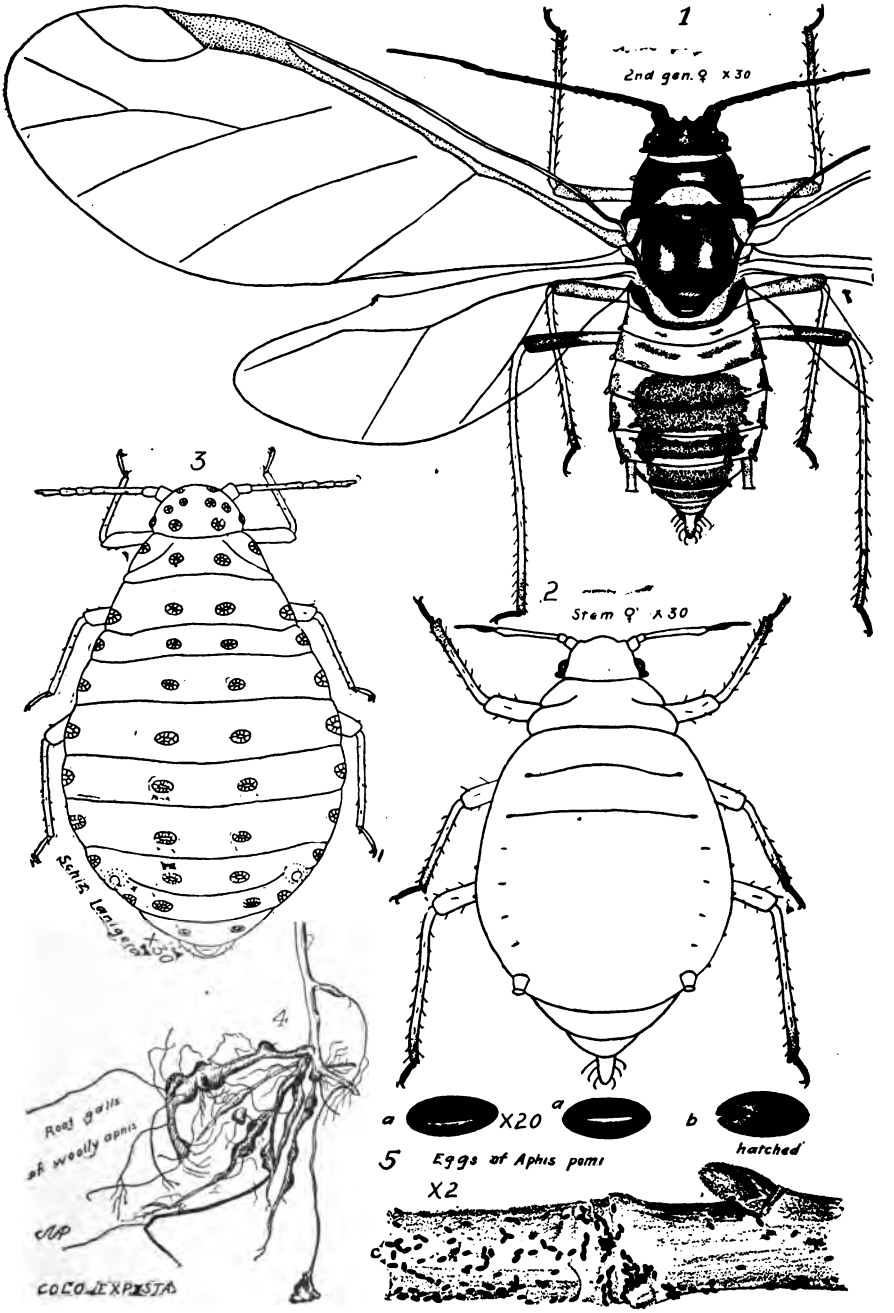


PLATE III. Fig. 1. Winged viviparious female of **Aphis bakeri;** 2. Stem mother of **Aphis bakeri;** 3. Wingless viviparious female of **Schizoneura lanigera** showing wax glands; 4. Root galls of wooly aphis of the apple; 5. Eggs of the green apple aphis (**Aphis pomi**), a. Eggs much enlarged; b. Egg shell after the louse had hatched; c. Apple twig with eggs upon it. Figures 1, 2, and 3 are enlarged 30 diameters; figure 5, a. and b. enlarged 20 diameters, c. enlarged 2 diameters.

M. A. PALMER, Artist.

LIBRARY OF THE UNIVERSITY

these stem females begin in the second generation to get wings and by the middle of June nearly all have left the trees and gone back to the clovers,** though some remain on the apple all summer. In the fall, many of the lice continue upon the clovers, going down close to the ground as cold weather comes on, and if the winter is not very severe, many will survive and continue to live and increase upon these plants throughout the year. Mr. L. C. Bragg has carried this louse through the winter in the laboratory upon red clover without trouble, but no eggs or egg-laying females were obtained.

So far as our observations have gone, this louse ranks next to the green apple aphis (*Ahpis pomi*) in numbers as a leaf infesting species of the apple. Mr. George P. Weldon reports it as having a tendency to accumulate in the apple blossoms, but we can hardly consider it a serious pest as yet in Colorado orchards.

Remedies the same as for the green apple aphis except that the application to kill the stem-mothers should be applied earlier, fully a week before the leaf buds begin to open at all.

THE EUROPEAN GRAIN APHIS

(*Aphis* (*Siphocoryne*) *avenae* Fab.)

This louse was found in a few apple orchards in the Grand Valley in 1907, and during the spring and early summer of 1908 it was observed in small numbers upon fruit spurs and succulent sprouts upon the trunks and large limbs of apple, pear and quince, in the orchards about Delta, Paonia, Montrose and Rockyford. Mr. Weldon reported it on apple at Montrose as late as June 18. In no case has it been found in sufficient numbers to do appreciable harm. In our experience the apple has been the preferred tree, and colonies upon the pear and quince have been rare.

This louse is readily separated from any of the other species here mentioned by the alternating transverse stripes of light and of dark green that cross the body above, by the light colored cornicles with black tips that are present in both young and adult forms, and by the very short second fork in the third transverse vein of the fore wing of the winged forms. It curls the leaves in a manner similar to the green apple aphis, *Aphis pomi.*

This insect was first described in Europe by Fab., as a grain louse, and it was not until 1894 that Mr. Theodore Pergande* discovered that it also feeds upon the leaves of apple trees during a portion of the year. It is said to be the most abundant apple leaf aphis of the eastern states.

** July 8, and again Aug. 16, '08, several colonies were found on apple about Fort Collins. Mr. Weldon reported this louse on apple at Delta, Colo., July 12, '08.

* Bull. 44, Div. of Entomology, U. S. Dept. of Agr.

LIFE HISTORY

The lice that first appear in the spring, the stem-mothers, hatch quite early, before the buds begin to open at all, from little shining black eggs that were deposited upon the bark of the twigs the preceding fall as in case of the common apple aphis. These stem-mothers are fully as forward as those of the clover aphis. They were mature and depositing young of the second generation in the orchards about Delta as early as April 14th this year.

The stem-mothers are rather deep green in general color with the head and tail ends of the body lightest in color, and the green may or may not take the form of lighter and darker transverse stripes. They do not acquire wings.

These first lice give birth to young for two or three weeks, or somewhat longer, and then die. Some of these second generation lice get wings and leave the trees. What lice are left produce a third generation which more largely become winged and leave, according to Pergande, to go upon certain grasses, especially oats, wheat, barley, and rye, where they continue to increase in numbers until late in the summer or early in the fall, and the winged migrants leave the grains and grasses again and return to the trees. Here they probably give birth to the true males and females, the latter of which deposit the eggs to remain over winter and hatch the stem-mothers to start the complex round of development for another year. (We have not yet traced the fall stages, nor have we been able to colonize it upon the grasses from the apple.)

We have not prepared technical drawings for this louse*

THE ROSY APPLE APHIS*

(*Aphis pyri* Boyer.)

A rosy tinted aphis of doubtful determination appeared in con-

---

* For illustrations of this louse see Pergande's figures, Bull. 44, Bureau of Ent.; also Sanderson's 13th Rep. Del. Exp. Sta., p. 139.

* This seems undoubtedly to be the louse that Sanderson described and figured in the 13th Annual Report of the Delaware Experiment Station (1901), as **Aphis sorbi.** Quaintance, Circular 81, Bureau of Entomology (1907), considers this to be **Aphis malifolii** Fitch, but Fitch describes this louse as being "of a shining black color throughout," and also states that "the legs are entirely black." None of the lice we have taken fill these requirements. Specimens of **Aphis sorbi** from Europe sent by Dr. Cholodkovsky and taken by him from **Sorbus aucuparia,** the original food plant of this species, fit well into Kaltenbach's description, and are doubtless that species. While the Colorado material possesses the four dorsal spines in front of the cauda and has the general color markings of **sorbi,** the dorsal tubercles are smaller and the lateral tubercles of the abdomen and thorax are much weaker. The larvae and pupae sent by Dr. Cholodkovsky have the cornicles unusually large and strongly tapering, while in our material the cornicles are not excessive in size. On the whole, our Colorado louse seems more nearly to correspond to the descriptions and figures of **Aphis pyri** Boyer, as given by Koch, and also by Buckton, and these descriptions and figures seem also to correspond very well with the **characteri-**

siderable numbers upon individual trees in some of the orchards of the Grand Valley last year. It attacks the leaves, causing them to curl exactly as in the case of the green apple aphis, but it is readily distinguished from that species by the pink color, especially of the wingless forms, and by the slight covering of a white powdery material. The winged lice have their head and thorax nearly black, but the abdomen is yellowish or rusty brown about the margins and dark brown over the middle portion, and never green or black as in the other species mentioned upon the apple. We are calling this, rather doubtfully, *Aphis pyri Boyer.* Remedies the same as for the green apple aphis (*Aphis pomi*).

THE SWEET CLOVER APHIS

(*Aphis medicaginis* Koch.)

This small black plant louse, while having a decided preference for certain legumes, as the sweet clovers, the locos, black locust, and wild Licuorice (*Glycyrrhiza lepidota*), feeds to some extent upon a very wide range of plants. We have frequently found it upon tender new shoots of apple and other fruit trees early in the season, and have received inquiries concerning it.

The wingless lice, when fully grown, are very deep shining black. Other wingless individuals of the colony are dark green to slaty gray but not black. From these colors alone the orchardist will be able to distinguish this from other species attacking the apple. Whether the colonies of this louse upon the apple came from stem-mothers hatching from over winter eggs has not been determined. We have never seen the eggs or true sexual forms of this species anywhere. It is not likely that this louse will ever become a serious orchard pest.

PEACH PLANT LICE

THE GREEN PEACH APHIS

(*Myzus persicae* Sulz.)

Plate II, Figs. 5 to 11.

This is by far the most abundant peach louse in Colorado. It seems to have been brought to this country from Europe where it was first described by Sulzer as a peach insect in 1761. Forty years later Shrank, finding it upon *Dianthus* (the pink) gave it the specific name *dianthi.* Koch in Germany redescribed it under

---

zation of malifolii, as given by Fitch. So we are calling our rosy apple aphis Aphis pyri Boyer, until we get further light upon the subject.

It might be added that the Aphis sorbi described by Buckton, Vol. II, p. 83, and which is referred to by Schouteden as this species in his paper ("Catalogue des Aphides de Belgique," p. 228), in "Memoires de la Soc. Entom. de Belgique, T. XII," is not sorbi unless both the descriptions and the illustrations are very incorrect, and the specimens we have from Dr. Cholodkovsky incorrectly determined.

the same name in 1854, and especially tells of taking it from Calla lily and the Oleander. Walker, an English writer about 1849, speaking of this louse says that it feeds upon at least sixty known plants and names the potato, turnip, cabbage, lily, carnation, tulip, tobacco, peach, nectarine, and many others. Buckton, in his "Monograph of British Aphididae" in 1879, speaks of this

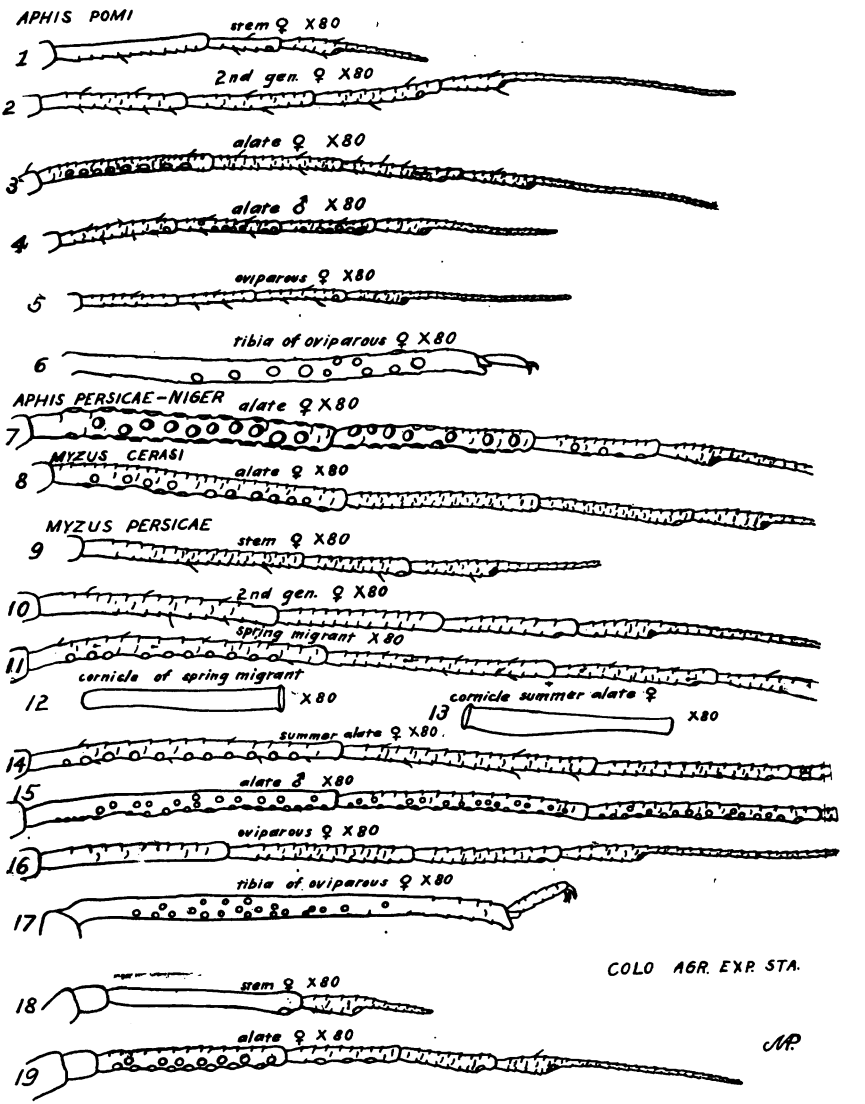

APHIS POMI
1 stem ♀ X80
2 2nd gen. ♀ X80
3 alate ♀ X80
4 alate ♂ X80
5 oviparous ♀ X80
6 tibia of oviparous ♀ X80
APHIS PERSICAE-NIGER
7 alate ♀ X80
MYZUS CERASI
8 alate ♀ X80
MYZUS PERSICAE
9 stem ♀ X80
10 2nd gen. ♀ X80
11 spring migrant X80
12 cornicle of spring migrant X80
13 cornicle summer alate ♀ X80
14 summer alate ♀ X80
15 alate ♂ X80
16 oviparous ♀ X80
17 tibia of oviparous ♀ X80
COLO AGR. EXP. STA.
18 stem ♀ X80
19 alate ♀ X80
M.P.

PLATE IV. Antennae, tibiae and cornicles of plant lice.
M. A. PALMER, ARTIST.

louse as being almost "polyphagus," on account of its feeding upon so many different plants.

In America this louse has also been reported under different names upon the peach, plum, cherry and man succulent plants, including several of our garden vegetables. The *Rhopalosiphum solani* of Thomas, occurring in abundance upon potatoes in Illinois; the *Siphonophora achryantes* of Monell, and the *Myzus malvae* of Oestlund* are almost certainly this *persicae* of Sulzer, which was described nearly a century and a half ago. Since arriving at the above conclusions* a letter has been received from Dr. N. Cholodkovsky of St. Petersburg, to whom specimens of this louse were sent and which were determined by him as being the *persicae* of Sulzer which he considers identical with the *dianthi of* Koch.

NAME AND LIFE HISTORY

There are two main reasons why this insect has been described under so many different names. It has a habit, which is not uncommon among the plant lice, of spending the fall, winter and spring of the year upon certain trees and shrubs, and the remainder of the year upon succulent vegetables. The winged form occurring upon the trees in the spring of the year (Plate II, Fig. 8) has its cornicles cylindrical in form while the winged individuals occurring upon succulent vegetation during the summer and fall, and those that return to the peach and other trees in September and October, (Plate II, Fig. 9) have their cornicles moderately swollen. The latter type of cornicle puts this louse into the genus *Rhopalosiphum,* while the former type of cornicle with the swollen antennal tubercles and first antennal joint, puts it into the genus *Myzus.* The other reason for the numerous names is its feeding upon a very wide range of plants.

So we are unable to avoid the rather sweeping conclusion that the green peach louse with its cylindrical cornicles, its pink egg-laying females in the fall and similarly colored stem-females in the early spring, is only the tree form of the green louse with club shaped cornicles that is so abundant in green-houses upon carnations, snapdragons, lilies, and many other flowering plants and out of doors cabbage, cauliflower, radish, turnip, potato, and a host of other vegetables, both wild and cultivated, which has been des-

* The **Rhopalosiphum sonchi** of Oestlund, which, in "Synopsis of the Aphididae of Minnesota," he seemed inclined to give up to **Rhopalosiphum dianthi** of Shrank, is probably a good species. At least, the native **Sonchus** growing in the vicinity of Fort Collins is badly infested with a **Rhopalosiphum that** is certainly distinct from the louse here discussed, and it fits in every particular the description given by Professor Oestlund for **R. sonchi.**

* See Journal of Economic Ent., Vol. I, No. 2, p. 84.

ignated by the various names given above along with others that we have not mentioned.

This insect, then spends the winter, either as wingless lice upon succulent vegetables where there is sufficient protection to enable them to endure the cold weather, or in the egg stage upon certain trees, chiefly the peach, plum, apricot, nectarine and cherry.

The eggs are shining black in color and are deposited in the axils of the buds for the most part, but some occur in crevices of the bark. The eggs hatch very early in the spring so that the young stem-mothers (Fig. 5) from them are often almost fully grown before the earliest peach or plum blossoms open. About the time the buds begin to open upon these trees, the stem-mothers are all of a deep pink color and begin giving birth to living young. These young (Fig. 6) instead of being pink like their mothers are pale yellowish green throughout their lives, and usually there is a median and two lateral dark green stripes passing over the abdomen. Very few of this brood attain wings. The third generation become very largely winged (Fig. 8) and begin leaving the trees upon which they were born about the middle of May in the peach growing sections of the state. By the middle of June these lice have almost completely left the trees and may be found establishing their colonies upon various succulent vegetables, a list of which is given below. At this date, (Aug. 1, '08) this louse in the insectary, bred directly from specimens taken from the peach in Fort Collins, June 20, are all apterous and the body color is a uniform pale yellow without green markings.

FOOD PLANTS

The plants upon which we have found this louse establishing colonies in Colorado are as follows:

IN GREENHOUSE

Snapdragon (**Antirrhinum sp.**)
Carnation (**Dianthus sp.**)
Potato (**Solanum tuberosum**)
Radish (**Raphanus sativus**)
Alternanthera.
Calla lily (**Richardia Africana**).
Lilium candidum.
Tulip (**Tulipa sp.**)
Cauliflower (**Brassica oleracea**).
Lactuca spicata.
Turnip (**Brassica rapa**).
Tobacco (**Nicotiana Tabacum**).
Egg-plant (**Solanum Melongena**).
Amaranthus sp.
Chenopodium album.
Water Cress (**Roxipa Nasturtium**).
Asparagus fern (**Asparagus sp.**)
Nasturtium (**Tropaeolum majus**).
Red Clover (**Trifolium pratense**).
White clover (**Trifolium repens**).
Verbena sp.
Russian thistle (**Salsola tragus**).
Cotton (**Gossypium herbaceum**).
Box-elder (**Rulac negundo**).
Snowball (**Viburnum opulus**).
Apple (**Pyrus malus**).
Wheat (**Triticum sativum**).
Grass (**Poa sp.**)
Corn (**Zea sp.**)
Willow (**Salix sp.**)
Castor bean (**Ricinus communis**).
Cineraria sp.
Pot Marigold (Calendula officinalis).
Fetid Marigold (**Drysodia sp.**).
Digitalis purpurea.
Primula Forbesi.
Stellaria media.
Iresine lindeni (Achyranthes).
Tomato (**Lycopersicum esculentum**).

Malva sp., native.
Tansetum balsamifera.
Poppy, cultivated.
Vinca sp.
Vicia sp.
Lupine, native wild pea.
Sugar beet **(Beta vulgaris).**
Cantaloupe **(Melo sp.)**
Watermelon **(Citrullus vulgaris).**
Native thistle **(Carduus sp.)**
Chrysanthemum sp.
Marsilea vestita.
Golden glow **(Rudbeckia sp.)**
Cactus **(Opuntia sp.)**

OUT-OF-DOORS

Trees upon which eggs are laid.
Peach **(Prunus persica).**
Plum **(Prunus domestica** and **Americana).**
Choke cherry **(Prunus Virginiana).**
Prune **(Prunus domestica).**
Nectarine.
Tame cherry **(Prunus cerasus).**
Apricot **(Prunus Armeniaca).**
Sand cherry **(Prunus melanocarpa).**

SUMMER FOOD PLANTS ONLY

Cabbage **(Brassica oleracea).**
Cauliflower **(Brassica oleracea).**
Rape **(Brassica napus).**
Turnip **(Brassisca Rapa).**
Potato **(Solanum tuberosum).**
Tulips **(Tulipa sp.)**
Pansy **(Viola tricolor).**
Pigweed **(Chenopodium album).**
Radish **(Raphanus sativus).**
Amarantus sp.
Chenopodium (Bonus-Henricus.)
Malvastrum coccineum.
Wild mustard.
Lepidium sp.
Dock **(Rumex sp.)**
Bursa Bursa-pastoris.
Tomato **(Lycopersicum esculentum),**
Water cress **(Nasturtium officinale).**
Apple **(Pyrus malus).**
Pear **(Pyrus communis).**
Lilac **(Syringa vulgaris).**
Castor bean **(Ricinus communis).**
Morning glory **(Convolvulus sp.),** wild
Hollyhock **(Althaea rosea).**
Horseradish **(Nasturtium armoracea).**

Immune plants—The following plants in the insectary were not infested: onion, beognia, oxalis, (four-leaved sorrel), and coleas.

Apparently, the only reason why the above list of infested greenhouse plants is not larger is because there was not a larger list of plants growing in the greenhouse at the time. It seems that this louse will feed upon almost any tender green foliage early in the spring, or late in the fall when most plants have died out and the lice are hard pressed for food.

A plant louse like this that is able to spend the winter either upon trees in the egg stage or as a louse upon succulent vegetables that are somewhat protected from the extremes of low temperature, and with such a wide range of food plants, has a remarkable power to continue its existence in a locality where it has once been introduced.

INJURIES

When the peach trees bloom, this louse often attacks the blossoms in numbers sufficient to blight them. After the fruit forms they sometimes attack the young peaches in sufficient numbers to cause them to wilt and drop. They also attack the leaves causing them to curl and turn yellow in color and, if the attack is very severe, many of the leaves drop.

NATURAL ENEMIES

This louse is attacked by a large number of insect enemies and it is probable that its severe struggle for existence with these

foes is what accounts for its wide range of food plants and its intricate life history.

The predaceous enemies such as lady-beetles, syrphus flies and lace-wing flies are very abundant about the colonies of this insect, and at least two small internal parasites* also destroy them.

REMEDIES

About a week before the buds open, spray the trees with the ordinary strength of kerosene emulsion (one-fifteenth oil) or with Black Leaf 1 to 65 in water, or with some other good plant louse spray recommended for the green apple aphis. After the trees have blossomed, if the lice become abundant at any time, spray as for the green apple aphis.

If the peach trees are to be treated with lime-sulfur for twig borer, or brown mites before the buds open, that application should kill nearly all of the stem mothers of this louse too, if made a week or ten days before the buds open.

THE BLACK PEACH APHIS

(*Aphis persicae-niger* Smith)

Plate I, Figs. 12, 13, 14.

This louse has long been known as a pest in peach orchards in the United States where is seems to be a native insect. This seems strange, however, as the peach is a native of Asia and appears to be the only food plant for this louse. We first noted the black peach aphis in Colorado in 1905. It has not become very generally distributed in the peach orchards of the State as yet, but is known to occur in a few localities upon the western slope and at Canon City. The infested orchards are so situated, however, that it will be an easy matter in a few years for the louse to distribute itself throughout nearly all the important peach sections.

It is important, therefore, for all who grow peaches to give the closest attention to their orchards for the purpose of detecting this louse as soon as it appears and destroying it, before it becomes so widely distributed that it cannot be kept under control.

APPEARANCE OF THE INSECT

This louse differs quite widely in its habits and appearance from other species that attack the peach, and is one that any fruit grower can readily determine if he will give close attention to the characterization here given.

---

* A species of **Lysiphlebus** destroys large numbers, especially in greenhouses, and we have also a number of the lice killed by a very minute Chalcid (**Aphelinus sp.**), which causes the lice to turn deep shining black in color. Lice parasitized by **Lysiphlebus** become swollen and turn to a gray, or light drab color. Those killed by the Chalcid retain their natural shape. Determined for us by Dr. L. O. Howard.

While this insect is known as the Black Peach Aphis, the greater number of the individuals in any colony are always of a reddish-yellow or amber color (Plate I, Fig. 13). It is only the full grown lice that are black, whether winged or wingless, and none of the individuals are ever green in color. The fully grown wingless lice are deep shining black and highly polished (Plate I, Fig. 12.

The other lice occurring upon the peach attack the foliage and blossoms and in some cases the young peaches, but none of them attack the year-old bark of the limbs as does this one.

LIFE HISTORY

This louse appears very early in the season. Last year it was found in Delta County and also in the vicinity of Palisades, early in February in considerable numbers, and badly infested twigs were received from Paonia that were taken March 18, 1908. These early appearing lice confine their attacks to the tender bark of the twigs and are nearly always most abundant at first upon small limbs or sprouts near the ground. The tender twigs may be literally covered with the lice before the leaves open at all. When the buds do open, exposing the leaves and blossoms, some of the lice migrate upon these tender parts. They may kill the little peaches, and if at all abundant upon the leaves, the latter curl and protect the lice from storms or from the insecticides that may be thrown upon the tree by the orchardist.

The lice that appear upon the trees early in the season are all wingless. The winged examples begin to appear in the vicinity of Grand Junction about the last of April. By the tenth of May these winged lice are usually very abundant, and by the middle of May, in our experience, the lice have begun to disappear from the peach trees, and very few have been found in the orchards after the 15th of June.

It is said that this louse migrates to the roots of the peach trees where it spends the fall and winter coming back to the top early in the spring. This part of the life history we have been unable to verify although we have dug about many peach trees in search of the lice.

That it is the habit of this insect to pass the winter upon the roots of trees seems highly probable as we have been unable to find any sexual forms or eggs, and we are not aware that any one has.

In the older peach growing sections of the country this aphis has been reported as frequently killing peach trees, especially small ones in nurseries.

PREVENTION AND REMEDIES

It is not very uncommon for horticultural inspectors to find

this louse present upon the roots of nursery stock that has been shipped into the state. Undoutbedly the lice present in Colorado today, have descended from those brought to the state in this manner, and not in the egg stage.

It is a matter of much importance then, to treat all nursery stock coming to Colorado in such a way as to prevent any possibility of introducing this louse into the peach orchards upon nursery trees.

This may be done either by a thorough fumigation of the stock with hydrocyanic acid gas; or by thoroughly and forcefully spraying it with kerosene emulsion, a good quality of whale oil soap, or a tobacco decoction, before planting.

If the louse has been introduced into the orchards and is found to be present upon peach trees it is highly important that the owner keep a very close watch over his trees especially in the early spring time for the purpose of detecting the first appearance of these lice, which would probably be during the latter part of February or sometime in March in the warmer sections of the state. In the colder sections where peaches are grown to some extent, the earliest date of their appearance would probably be the latter part of March or very early in April. As indicated above, the louse may become very abundant before the buds open at all, and that is when treatment of orchards trees can be made most effective and with least expense. So far as our observations have gone, the lime-sulfur preparations have not been satisfactory for the control of this louse, but it is very readily killed by the ordinary application of soaps, tobacco preparations or oil emulsions. We would especially recommend kerosene emulsion that is 1-15 oil; "Black Leaf," 1 gallon in 65 gallons water; or home made tobacco decoction. If the treatment is made one week before the buds begin to open, the green peach aphis will also be killed by the same application.

Thorough treatment should always be made before the winged forms begin to appear, which may be as early as the middle of April.

This louse is very gregarious in habit so that it will often be the case that one or two trees, or even one side, or a few limbs upon a tree, may be quite badly attacked when no other infested trees are found in the orchard.

PLUM LICE

Besides being attacked somewhat by the green peach louse (*M. persicae*) plum and prune trees have three other species of plant lice of considerable importance in Colorado.

THE MEALY PLUM LOUSE

Hyalopterus arundinis (Fab.)

This is a light green louse that colonizes the underside of the

leaves of plum and prune trees. It often is so numerous that the under leaf surface is completely covered by the lice.

The stem-mothers hatch from black shining eggs deposited upon the twigs of the trees late in the fall. They locate upon the underside of young growing leaves where they give birth to a large number of living young which, so far as we have observed, do not acquire wings. At Austin, Colorado, May 22, '08, many of the second generation were mature and producing young. In the earlier sections this louse becomes very abundant by the 10th to the 15th of May and may continue to about the 15th or 20th of July when nearly all will have acquired wings and left the trees. About Fort Collins, at least, we find that occasional colonies of this louse remain upon plum trees throughout the summer.

Upon leaving the plum, the lice go to certain grasses to feed during the summer. We have specially found it infesting Reed-grass, *Phragmites Phragmites,* on wet ground and along ditches upon the western slope in Colorado.

About the middle of September* the fall migrants begin to return to the plum trees and to give birth to the sexual males and females. The males are winged and the females wingless. The latter deposit the eggs that remain over winter.

This louse may be easily distinguished from other plum infesting species by its light green color, with three longitudinal darker stripes above, the white powdery covering to the body, the long narrow body, the short cornicles, and the small second fork in the third sector of the fore wing. The leaves when loaded with this louse, may drop and become yellow but they do not curl as is so often the case in plant louse attacks.

REMEDIES

The lice will leave of their own accord by about July 10 in the warmer portions of the state and a little later in other sections. If found very abundant before July 1st, it will doubtless pay to make a thorough spraying with kerosene emulsion or Black Leaf as recommended for the green apple aphis.

This louse seems to have few natural enemies to keep it in check.

THE HOP PLANT LOUSE

(*Phorodon humuli* Schrank)

This is another green louse that inhabits the plum as a winter host plant. This louse is specially noted for its severe injuries to the hop during the summer months. It is generally distributed in the state and has frequently been taken by us upon both cultivated

* September 16, 1906, is our earliest date for return migrants to the plum.

and wild hops and upon plums.

At Fort Collins we have followed it upon the plum in moderate numbers throughout the entire season, and Mr. W. T. Clark* has reported it remaining upon the hop vines in California until the males and egg-laying females have been produced. So it seems probable that this louse can exist from year to year upon either of these food plants in the absence of the other.

For an excellent account of the life habits of this insect and colored figures of the different stages, see an article by C. V. Riley in Department of Agriculture Report for 1888, p. 93.

While we have not observed the stem-mothers in Colorado, we find the louse appearing during May and the early part of June upon the leaves of plum trees. Most of the lice acquire wings and leave early in July in the vicinity of Fort Collins, though on July 8, 1907, trees were seen badly infested with this louse and there were many wingless adult females still present.

APPEARANCE OF THE LICE

The wingless lice are light green or greenish yellow without noticeable markings of other colors. The winged lice have the same general body color with head, plates of the meso-thorax above, and a few dashes upon the abdomen black. All the lice are specially marked by having upon the head, at the base of each antenna, a prominent tubercle or tooth, and a less prominent one projects from the inner side of the first joint of the antenna.

About the middle of September at Fort Collins the winged return migrants begin to come from the hops and alight upon the leaves of the plum. A note made at that place October 3, '07, reads: "The winged migrants are fairly common on plum leaves now and most of them have a small colony of young surrounding them." These young develop into the wingless egg-laying females (and possibly winged males also) and a little later the eggs are deposited upon the twigs to live over winter.

REMEDIES

The same as for the green apple aphis.

THE RUSTY BROWN PLUM LOUSE

(*Aphis setariae.* Thos.)

This plum louse is readily distinguished from any of the other species mentioned in this bulletin by its dark rusty brown color together with the conspicuous white base of the antennae, entire tibiae, and tail or cauda.

This louse appears early in the season upon the bark and leaves of the tender new shoots of plum trees. We have found it

* Bull. 106, Calif. Experiment Station, 1904.

specially upon the red or Americana plums. Throughout the season it seems to have a strong tendency to cluster upon the bark of the tenderest new growth.

The louse is nearly always accompanied by ants, that attend it for the honey dew that is secreted. Usually in the colonies a few larvae of one of the small black Coccinellids (*Scymnus* sp.) can be seen. They are recognized at once by the white secretion that covers their bodies.

This louse remains upon the plum throughout the entire year. We have found it in many places east of the mountains both in the vicinity of Fort Collins and in the Arkansas Valley, but we have not taken it on the western slope. It often becomes abundant enough to be a very serious pest, but on account of its body being entirely free from any powdery secretions, it is readily treated and destroyed. From about the first of August on through the summer we have also found this louse upon barnyard grass (*Echinochloa Crus-galli.*) The louse becomes darker in color late in the season and the oviparious female in the fall is almost black. The small winged males are black in color. The egg-laying females are wingless and, in the laboratory, Mr. Bragg succeeded in getting them to lay eggs quite freely upon plum twigs, but he was unable to find any of the eggs upon infested plum trees out of doors. The lice upon plum trees during September and October were all apterous except the males, but whenever found upon barnyard grass there were many winged individuals present that seemed to be fall migrants.

Mr. J. T. Monell* reported this louse upon *Panicum proliferum*) in Missouri, and Professor O. W. Oestlund** reports it upon fox-tail (*Setaria glauca*), barnyard grass (*Echinochloa Crus-galli*) and Virginia Creeper (*Ampelopsis quinquefolia* in Minnesota.

REMEDIES

The remedies for this louse are the same as for the green apple aphis, without the early treatments for the destruction of eggs.

THE BLACK CHERRY LOUSE

(*Myzus cerasi* Fab.)

Plate II, Figs. 1, 2, 3, 4.

This is an insect that has long been known in Europe and for more than half a century, at least, has been a pest upon cultivated cherries in the eastern portion of this country. It is generally distributed through the orchards of the eastern slope of the Rocky Mountains in Colorado and has found its way into a few orchards,

* Bull. 5, U. S. Geol. Survey, p. 23, 1878.
** Aphids of Minn., p. 67, 1887.

in the valley of the Gunnison. Prompt action on the part of the orchardists where it occurs would almost exterminate it from our Western Slope.

Both the winged and wingless forms of this louse are deep shining black, the body is rather broad and flat and the cornicles are long and clyindrical. Cherry foliage may be fairly blackened by the lice before the early cherries mature.

Dr. C. M. Weed,* who studied this louse in Ohio, found winged lice appearing in great numbers about June 10 to July 1st, and all lice disappeared by the latter part of July and remained off the cherry until late in September when he began to find winged migrants again. Though no alternate food plants were found, Dr. Weed was convinced that such plants existed and that it is the instinct of the louse to entirely leave the cherry trees during the late part of the summer. We have followed this louse quite closely for two years past about Fort Collins and have found its habits about as follows:,

The lice first attract attention about the last of May upon sprouts about the trees, then upon the lower limbs, and by the middle of June may be all through the trees. About the first week in July their enemies, especially the lady-beetles, become very abundant and the lice rapidly disappear so that by the middle or latter part of the month they can only be found in scattered isolated colonies. Some of these escape their enemies and the lice gradually increase in numbers again late in August and in September, but, so far as we have observed, do not again become very numerous. At least, this louse did continue in this manner throughout the entire summer in 1907 and 1908 about Fort Collins where it was closely watched for us by both Mr. L. C. Bragg and Mr. T. D. Urbahns.

Up to about June 15th. at Fort Collins, practically no winged lice can be found and by July 1st. the great majority of the lice are either winged or pupae, and a good proportion of winged individuals continue in the colonies throughout the season.

Besides the observations of the writers, Mr. L. C. Bragg has spent a considerable portion of his time every week of the year for more than two years past inspecting plants of every kind growing in the vicinity of Fort Collins, yet this louse has never been seen by any of us upon any plant but the cultivated cherry. We are obliged to conclude, therefore, that this louse has no other regular food plant in Colorado.

REMEDIES

This louse should be treated with kerosene emulsion or one of the tobacco preparations before the winged lice appear to spread

* Bull. Ohio Experiment Station, Technical Series, Vol. I, No. 2, p. 111, 1890.

the species from tree to tree. The earlier this is done after the lice first appear the better, for then they are nearly all accumulated upon a few sprouts or limbs near the ground.

PREPARATION OF THE INSECTICIDES MENTIONED IN THIS BULLETIN.

KEROSENE EMULSIONS

The standard formula for mixing the stock solution of kerosene emulsion is as follows:

Water 1 gallon.

Tak-a-Nap, Whale-oil, or Laundry soap 1-2 pound.

Kerosene, 2 gallons.

For use, dilute with water to secure the desired percentage of oil.

For example, if a spray containing 5 per cent oil is desired, use 3 3-4 gallons of the stock solution, and dilute with water to make 50 gallons of spray. If a 6 per cent spray is desired, use4 1-2 gallons of the stock solution to make 50 gallons of spray, or if a 7 per cent spray is desired, use 5 1-4 gallons of the stock solution in making up 50 gallons, or practically 1 part stock solution to 9 parts of water. This last named strength is the one most commonly used for the destruction of plant lice upon plants while they are in foliage. Larger amounts of the stock solution may be prepared using the same ratio. If a stronger spray is to be used than those given above, it is only necessary to dilute with a smaller proportion of water, bearing in mind in computing the percentage of oil in the spray that the stock solution is two-thirds oil.

The necessary steps are: Dissolve 1-2 pound soap in 1 gallon boiling water. While boiling hot add this to 2 gallons kerosene and briskly agitate for about five minutes. A creamy mixture will be formed which, when diluted with water, will mix readily without allowing free kerosene to rise to the top. After agitating, add a small quantity of the stock solution to a bucket of clear water for trial. It should mix completely through the water, like milk. If it rises to the top as free oil, the stock solution will have to be heated again to boiling and churned until it will stand this test. To avoid accidents, the boiling solutions should be removed from the fire when it is mixed with the kerosene. An emulsion can be formed with greater ease if the oil is also warmed, but the heating of kerosene over a live fire, for safety, should only be attempted out of doors and away from all buildings. The mixture must be watched closely also to prevent its boiling over the sides of the vessel and igniting.

Mixing the emulsion is not a difficult operation. It can be done by any orchardist. The essentials of success are in having the soap suds *boiling hot* when the solutin is added to the kerosene, in

giving *immediate and thorough agitation* when the boiling soap-suds and kerosene are poured together, and in the use of clean soft water.

The apparatus may vary with the amount to be prepared. Those preparing to use several spray tanks of the material and possessing a gasoline power spray outfit find it most convenient to perform the agitation by placing the boiling hot soap-suds and the kerosene together in the spray tank and forcing the mixture through the pump. This churns the liquid thoroughly. Mr. B. A. Smith of Grand Junction, successfully prepares enough of the stock emulsion at one time in this way for five two-hundred gallon tanks of 6 per cent spray. He first dissolves in a home-made cooking vat with galvanized iron bottom and wooden sides, thirty pounds soap with thirty gallons of water, and when this is boiling hot it is poured into the spray tank upon 60 gallons of kerosene previously emptied into the tank. The gasoline engine then forces the mixture through the pump and a short spray hose back into the tank under a high pressure for several minutes until oil and soap-suds are completely combined. The whole solution, about 100 gallons, is then run off into an extra dismounted spray tank and 1-5 of the stock solution used for each 200 gallon tank, thus giving approximately 6 per cent oil in the spray. The apparatus is equipped with a mechanical agitator in the tank which operates while the emulsion is being made, but the action of these mechanical agitators will not alone form a good emulsion, and the mixture must also be pumped as described out from the tank through a spraying nozzle hose and back into the tank again.

Enough for a two hundred gallon spray tank may be made in a 50 gallon barrel fitted with a good hand barrel pump for agitation. Smaller amounts may be prepared with wash-boilers or tubs as heating vessels for the soap-suds, and to contain the oil and soap-suds when being emulsified and a good hand bucket pump will perform the agitation. If a very small quantity is to be used for a few house plants an egg beater will suffice for the agitation.

Many kinds of soap may be used to prepare the emulsion. Tak-a-Nap soap, whale-oil soap and Laundry soap have been most commonly used by the growers. The cost of the soaps should be considered. Tak-a-Nap soap is a soft soap and disolves readily. It should be heated to boiling in water when dissolved the same as other soaps insure the best results, instead of attempting to combine soap-suds and kerosene cold.

Those who have trouble in making kerosene emulsion can procure a commercial article known as "Aphisicide" manufactured at Grand Junction, or else use some other good contact insecticide instead.

PRECAUTIONS

When preparing and using kerosene emulsion remember:

To use soft clean water is possible.

To have the mixture as hot as possible for emulsifying.

To see that the oil, or mixture of oil and soapy water does not boil over into the fire.

To see that the oil does not separate to form a layer of kerosene on top. If this condition exists, the last of the barrel or tank will be almost sure to burn the foliage.

To remember that the strength of the emulsion depends upon the percentage of oil it contains.

To use kerosene emulsion alone, do not try to combine it with arsenical sprays.

To apply forcefully and thoroughly so as to wet the insects as it only kills by coming in actual contact with their bodies.

TOBACCO DECOCTION

Tobacco stems or tobacco dust two pounds.

Water four gallons.

Put the tobacco in the water which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simmer, but not boil,* for fully one hour, when the liquid is ready to be drained off and applied.

If the whole leaf tobacco is used, prepare as above using one pound of tobacco to each four gallons of water.

No lime or other akaline substances should be added to the tobacco while cooking. Apply at once, or within a few days after making.

BLACK LEAF

There is nothing to do in the preparation of Black Leaf except to thoroughly stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the Black Leaf will be found sufficient for each seventy gallons of water. If in the treatment of any louse this does not seem sufficient it may be used in the proportion of one gallon to sixty or sixty-five gallons of water. In fact, we have usually succeeded in killing plant lice with this preparation used in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

If this substance is not obtainable in your home town it may be procured from the Watkins Merchandise Co., Denver, or from The Kentucky Tobacco Product Co., Louisville, Kentucky.

*Dr. W. P. Headden, Station chemist, says that nicotine will be partially driven off by boiling. A distillate he prepared killed lice when diluted to 1-8 strength.

MISCIBLE OILS

There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," "Target Brand Scale Destroyer" or "Killoscale" add the oil directly to the water with a little stirring. One gallon of the miscible oil in fifty gallons of water will make a two per cent. mixture, which in most cases, should be strong enough to kill plant lice if thoroughly applied.

LIME-SULPHUR MIXTURE (FOR WINTER SPRAY ONLY)

FLOWERS OF SULFUR, FIFTEEN POUNDS
Good lump lime, fifteen pounds. Water, forty-five gallons.

This is the 1-1-3 lime-sulfur mixture. First slake the lump lime with sufficient warm water, and while still boiling hot, add the sulfur and stir it in. Place over the fire and continue the boiling, adding water when necessary, until the mixture changes to a deep reddish brown color which indicates that the lime has cut the sulfur. It will be necessary to boil steadily for about forty minutes to one hour to produce this result. The mixture should then be diluted to form forty-five gallons of the spray, and should be applied at once.

When the lime-sulfur mixture is placed in the barrel or tank it should be strained through gunny sacking to take out all lumps that would clog the spray nozzle. If allowed to stand for any great length of time after being prepared, the lime sulfur crystalizes out to a considerable extent. In such a case it is necessary to heat the mixture again before applying so as to dissolve all the crystals. If the crystals are re-dissolved the mixture will be as strong as before.

To make 1-1-2 lime-sulfur mixture, prepare as above using only thirty gallons of water for the fifteen pounds of lime and the fifteen pounds of sulfur.

For the 1-1-4 lime-sulfur mixture prepare in the same manner, but dilute to sixty gallons before applying.

REX LIME-SULFUR

We have found the Rex lime-sulfur in the proportion one gallon of the Rex to seven or eight gallons of water to be just about equal in effect to the 1-1-3 home made lime sulfur preparation.

WHALE-OIL OR FISH-OIL SOAPS

The so-called Whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six or eight gallons of water. There are numerous brands of these soaps upon the market. Those that we have used successfully are Good's Whale Oil Soap and Bowker's Tree Soap.

TABLE OF CONTENTS

Introduction Page
General Structure and Habits of the Plant Lice 3
External Structure of the Aphids 4
APPLE PLANT LICE 5
The Wooly Apple Aphis 5
Past History 5
The Louse Described 6
Life History 7
Birth Record of Winged Migrants 10
Parts of Tree Most Attacked; Injuries 11
Prevention. Natural Enemies 12
Remedies Above Ground; Kerosene Emulsion 13
Scalecide and Other Miscible Oils; Soaps ; "Black Leaf" 14
Tobacco Decoctions 15
Lime-Sulfur Sprays 16
Late Winter or Early Spring Applications; Tanglefoot Bands 16
Mounding and Cultivating; Trimming 17
Treatment Below Ground 17
Experiments in Grand Valley 18
The Applications and Their Results 18
Experiments for the Destruction of Woolly Apple Aphis 19
Experiments in the Orchard of J. Cornetto 20
Carbon Bisulfid. Tobacco Dust and Stems; Decoctions 21
Black Leaf Dip 22
Scalecide; Soaps 22
Some Wholly Unsuccessful Substances 22
Root Treatment of Nursery Stock 22
Conclusions as to Best Methods of Treatment 22
The Green Apple Aphis; Food Plants 23
Life History; The Eggs 24
The Stem Mothers; Second Generation 25
Wingless Female of Summer Generations; Winged Females 26
Males; Egg-Laying Females; Natural Enemies 26
Remedies; Winter and Early Spring Spray 27
The Clover Aphis 28
Food Plants and Life History 28
The European Grain Aphis 30
The Rosy Apple Aphis 31
The Sweet Clover Aphis 32
PEACH PLANT LICE 32
The Green Peach Aphis 32
Name and Life History 34
Food Plants 35
Injuries; Natural Enemies 36
The Black Peach Aphis; Appearance; Remedies 37
Life History 38
Prevention and Remedies 38
PLUM LICE 39
The Mealy Plum Louse 39
Hop Plant Louse 40
Rusty Brown Plum Louse 41
BLACK CHERRY LOUSE 42
PREPARATION OF THE INSECTICIDES MENTIONED 44
Kerosene Emulsions 44
Precautions 46
Tobacco Decoction. Black Leaf 46
Miscible Oils 47
Lime-Sulfur Mixture 47
Rex Lime-Sulfur 47
Whale-Oil or Fish-Oil Soaps 47

EXPLANATION TO PLATES

Plate I, page 16: The Green Apple Aphis, *Aphis pomi*—1, young stem mother; 2, adult stem mother; 3, adult apterous viviparous female, second generation; 4, young female, second generation; 5, winged viviparous female of third generation; 6, pupa of preceding; 7 and 8, apterous male and female. The Woolly Apple Aphis, *Schizoneura lanigera*—9, apterous viviparous female; 10, fall migrant; 11, over-winter young. Black Peach Aphis, *Aphis persicae-niger*—12, adult apterous viviparous female; 13, young female, first instar; 14, alate female; 15, *Chrysopa* sp. and eggs; 16, cocoon of preceding.

Plate II, page 32: Black Cherry Aphis, *Myzus cerasi*—1, apterous viviparous female; 2, alate viviparous female; 3, male. Green Peach Aphis, *Myzus persicae*—4, young stem mother, first instar, 5, adult stem mother; 6, young of stem mother; 7, apterous viviparous female of second generation; 8, spring migrant; 9, fall migrant; 10, egg-laying female; 11, eggs. Figs. 12, 13, 14, 15, the adult, the larva, the pupa, and the eggs of the common lady beetle, *Hippodamia convergens*.

Miss M. A. Palmer, Artist.

ERRATA

Plate IV, Fig. 4, read *apterous* for "alate."
Page 32, line 14 from bottom, read, *Figs. 4 to 11.*"

Bulletin 134. Sept. 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Orchard Plant Lice

AND

Their Remedies

BY

C. P. GILLETTE

E. P. TAYLOR

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		TERMS EXPIRE
HON. J. L. CHATFIELD,	Gypsum,	1909
HON. B. U. DYE,	Rocky Ford,	1909
HON. B. F. ROCKAFELLOW, President,	Canon City,	1911
HON. E. H. GRUBB,	Carbondale,	1911
HON. R. W. CORWIN,	Pueblo,	1913
HON. A. A. EDWARDS,	Fort Collins,	1913
HON. F. E. BROOKS,	Colorado Springs,	1915
HON. J. L. BRUSH,	Greeley,	1915

GOVERNOR HENRY A. BUCTEL,
PRESIDENT BARTON O. AYLESWORTH, } *Ex-officio.*

A. M. HAWLEY, SECRETARY CHARLES SHELDON, TREASURER

EXECUTIVE COMMITTEE IN CHARGE

B. F. ROCKAFELLOW, *Chairman*

A. A. EDWARDS. B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*,	IRRIGATION ENGINEER
C. P. GILLETTE, M. S.,	ENTOMOLOGIST
W. P. HEADDEN, A. M., PH. D.,	CHEMIST
WENDELL PADDOCK, M. S.,	HORTICULTURIST
W. L. CARLYLE, M. S.,	AGRICULTURIST
G. H. GLOVER, M. S., D. V. M.,	VETERINARIAN
W. H. OLIN, M. S.,	AGRONOMIST
W. G. SACKETT, B. S.,	BACTERIOLOGIST
R. E. TRIMBLE, B. S.,	ASSISTANT IRRIGATION ENGINEER
F. C. ALFORD, M. S.,	ASSISTANT CHEMIST
EARL DOUGLASS, M. S.,	ASSISTANT CHEMIST
S. ARTHUR JOHNSTON, M. S.,	ASSISTANT ENTOMOLOGIST
B. O. LONGYEAR, B. S.,	ASSISTANT HORTICULTURIST
E. B. HOUSE, M. S.,	ASSISTANT IRRIGATION ENGINEER
F. KNORR, B. S.,	ASSISTANT AGRONOMIST
P. K. BLINN, B. S.,	FIELD AGENT, ARKANSAS VALLEY, ROCKY FORD
E. R. BENNETT, B. S.,	POTATO INVESTIGATIONS
MIRIAM A. PALMER,	ARTIST
L. C. BRAGG,	ASS'T IN ENTOMOLOGY

STATE FRUIT INVESTIGATIONS

O. B. WHIPPLE, B. S., GRAND JUNCTION,	FIELD HORTICULTURIST
GEORGE B. WELDON, B. S , DELTA,	FIELD ENTOMOLOGIST

OFFICERS

PRESIDENT BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S.,	DIRECTOR
A. M. HAWLEY,	SECRETARY
MARGARET MURRAY,	CLERK

ORCHARD PLANT LICE AND THEIR REMEDIES.*

C. P. GILLETTE AND E. P. TAYLOR.

The plant lice that are commonly designated as "aphids" have very similar habits, structures, and remedies. These should be known and understood by the farmer and fruit grower who have to contend with them. Nearly all of these lice are rather easily destroyed when proper remedies are intelligently applied to them. Probably the plant lice here mentioned are the most serious orchard pests in Colorado at the present time.

GENERAL STRUCTURE AND HABITS.

All of the plant lice get their food by inserting a beak and sucking the sap of the plant. They never eat away the tissue of the leaf.

Throughout the entire summer, from spring to about the first of September, all of our plant lice that infest orchard trees, increase in numbers by giving birth to living young. If eggs are laid at all they are deposited by the last brood of females in the fall. From the fact that a single louse is usually able to give birth to from 75 to 150 young, and as they mature in about eight to ten days after being born, it will readily be seen that the plant lice are capable of increasing with wonderful rapidity. This accounts for the fact that the lice may nearly all be killed from a tree and that tree be very seriously infested with the lice again within a few weeks. Usually the last brood in the fall are about one half males and one half females. These females deposit the eggs that live over winter and the lice all die. We have an exception of this rule, however, in case of the woolly apple aphis which lives over winter as young or partly grown lice upon the trunk and branches, and in all stages of growth upon the roots of the trees.

Plant louse eggs usually hatch in the spring a little before the leaf buds begin to open on the trees that they infest. These early lice hatching from the eggs are always wingless in the species mentioned in this bulletin, and are called stem-mothers. These stem-mothers mature in a short time, are all females, and begin giving birth to young lice which constitute the second brood. It is seldom that the second brood of lice have more than a very few winged ones. The remainder of the life history of these lice will be given under the different species treated.

---

*This bulletin is an abbreviated edition of Bulletin 133, "A Few Orchard Plant Lice," by C. P. Gillette and E. P. Taylor, and is prepared to give the most important information needed by fruit growers. Bulletin 133 gives a much fuller account of the plant lice, and is illustrated by colored plates of some of the most important species. The technical matter, and that which does not relate to the economical side is omitted from this edition, which is intended to meet the needs of most people.

Bulletin 133 will be sent on request made to the Director.

ANTS AND HONEY DEW

Wherever the aphids are abundant, it is usually true that ants may be seen running over the infested tree or plant. It is often thought by the orchardist or farmer that the ants are present to destroy the lice, but this is probably never the case. Nearly all plant lice excrete from their bodies a sweet liquid known as "honey dew." This liquid, gathering upon the leaves of the plants, cause them to be shiny and sticky as if they had been varnished. The ants are very fond of this liquid and visit the lice to obtain it, and are always very careful not to injure the plant lice themselves.

NATURAL REMEDIES

The plant lice are greatly lessened in numbers every year by insect enemies. Most important among these are the "lady-beetles," the "syrphus flies," and the "lace-wing flies" or "aphis-lions." Wherever these are found upon the infested plants they should be carefully protected as they often destroy the lice so completely that it is not necessary to make any application to kill the lice artificially.

REMEDIES

The most common remedies for the destruction of plant lice are kerosene emulsion, tobacco decoctions, or soapy preparations. An insecticide that will destroy one plant louse will usually be effectual in destroying any other, if a thorough application is made.

Plant lice fly so freely from one orchard to another that it is very important that all of the orchardists in a community spray their trees whenever the lice are abundant. If one man should fail to do this, the plant lice leaving his trees, would in nearly every case, be sufficient to thoroughly colonize all of the orchards near him. Co-operation then is very important in any campaign against plant lice.

APPLE PLANT LICE.

WOOLLY APPLE APHIS. (*Schizoneura lanigera Hausm.*)

This is probably the most serious apple pest in Colorado. It is a bark feeder, and it attacks both the roots, the trunk and the limbs of the trees, but does not feed upon the fruit or foliage. This louse is readily recognized on account of its being covered with a white woolly secretion which has suggested its common name. Upon the trunk and branches the lice attack either the tender bark about the scars or the bark of tender new shoots. Below ground, the lice attack the bark of the smaller roots causing warty swellings upon them. If very abundant, the roots are often completely covered with these smooth wart-like growths which sometimes cause the roots to die and rot off. When very abundant upon the very rapidly growing twigs, these lice often produce abrupt swellings due to the thickening of the inner bark. Sometimes these swollen portions of the limbs crack open lengthwise and the limbs may be sufficiently injured to case them to die. Severest injury is done to the tops where there is the tenderest and most rapid growth as in grafts and water sprouts.

LIFE HABITS

The life habits of this insect may be briefly stated as follows: Early in the spring there will be a few living lice in protected places beneath the bark or under the dead bodies of the lice that were killed the previous fall, There will also be a large number of lice living over upon the roots of the tree beneath the surface of the ground. The lice that live over on top are all very small. Those living over upon the roots are of all sizes from the smallest to those that are fully grown. By the time that the buds begin to open in the spring, the lice that live over on top will locate on tender new bark and insert their beaks and begin to suck the sap of the tree and to grow in size. At the same time a greater or less number of small lice that live over winter about the crown of the trees, and perhaps some that came up from the roots, migrate to the top and begin to feed and grow. These lice start the round of development for the year on the tree tops. They are usually first detected by the fruit grower when the little lice have grown enough to secrete a white covering to their bodies which makes them appear like little mouldy spots upon the bark. These lice increase very rapidly in number so that by the middle of June or first of July the tree may be very badly infested and the cottony secretion may be so heavy as to hang down and even fall from the bodies of the lice.

The lice are all wingless until about the first of September when an occasional wigned louse may usually be found upon the trees. These lice leave the trees where they develop and fiy to others. Each of these winged lice gives birth to about four or five males and as many females. Before winter comes on, each female deposits a single egg and dies. No one seems to have followed this part of the life history of the woolly aphis in the orchard. It is supposed that these eggs hatch the following spring and start new colonies.

Upon the roots of the trees the woolly aphis lives in large numbers the year around, the only difference in the winter being that the lice reproduce very slowly, so do not increase much in numbers. The cold weather seems never to be sufficient to kill them even in our coldest climates where the apple is grown.

PREVENTION

Prevention is nearly always better than the cure. Great care should be taken therefore, when setting out a new orchard, to prevent the introduction of this lousé. Orchards are usually infested by the lice that are upon the roots of the nursery trees when they are set out. All nursery stock should be thoroughly disinfected either by fumigation with hydrocyanic acid gas, or by very thorough spraying of the trees, both roots and branches, before they are set, with one of the remedies mentioned below for spraying tops.

One method of preventing injuries from this louse is to have all apple trees upon Northern Spy roots, as Northern Spy seems never to be seriously attacked by this insect.

If nursery stock is received with roots "puddled," covered with mud, the purchaser should insist upon this mud being thoroughly washed off, and the roots treated for woolly aphis, as this is one of the methods that the nursey man has of covering up woolly aphis upon his nursery stock.

To prevent the spread of the woolly aphis from tree to tree and orchard to orchard, the lice should be well cleaned out of the orchard before the first week of September as it is about this time when the winged lice begin to fly about to spread the species.

REMEDIES ABOVE GROUND

Wherever this louse can be reached by sprays it may be destroyed like other plant lice, but one precaution is necessary, the spray must be applied with sufficient force to remove or penetrate the wooly covering. There are several spray materials that we have found entirely successful when thoroughly applied to this insect.

Kerosene Emulsion—According to our experience, a good kerosene emulsion has no superior for the destruction of this insect. It seems to penetrate the woolly covering rather better than most other insecticides. When used in the ordinary strength (1/15 oil) we have always found it efficient. In the proportion of one-twentieth oil (5%), we have usually found it sufficiently strong if applied with a good deal of force and thoroughness.

Directions for preparing kerosene emulsion are given on a later page.

To be most successful, apply as a moderately coarse spray and with a pressure, if possible, of one hundred forty to one hundred eighty pounds.

Scalecide and Other Miscible Oils—There are upon the market a number of so-called miscible oils which, when put into water, break up at once into very fine particles forming a milky white emulsion. These oils we have found fairly successful. Two to three gallons are used in each one hundred gallons of water. After being prepared, if these oils separate out so as to form an oily film upon the surface of the water, they should not be used.

Soaps—We have found the standard whale-oil soaps such as "Good's Whale Oil Soap" and "Bowker's Tree Soap" quite effectual for the destruction of this louse when used in the proportion of one pound of soap to each six or eight gallons of water.

Black Leaf—The Kentucky Tobacco Product Co., of Louisville, Kentucky, manufacture a tobacco extract which they sell under the above trade name and which has become very popular among the orchardists of Delta County, Colorado, as a spray for orchard plant lice. We have tested it quite thoroughly and have found it very efficient for the woolly aphis if used in the proportion of one gallon of the Black Leaf in sixty-five to seventy gallons of water. In fact, we have usually been successful when using Black Leaf as weak as one gallon to one hundred gallons of water. This strength, however, requires very thorough application. It would be a good plan for any one to treat a few trees with varying strengths of this or any other insecticide for the destruction of lice a day or two before taking up his general spraying work, for the purpose of determining whether or not the strength that he contemplates using is sufficient to kill the lice. In this way he may save many dollars, from using the insecticides in a strength that will not do the work or in a proportion unnecessarily strong.

Tobacco Decoction—If any prefer to make their own tobacco decoctions, they may use tobacco stems or tobacco dust or whole-leaf to-

bacco. Fruit men, however, have not reported very uniform results from their own preparations. This may be due to adulterations in the tobacco or from different methods of preparing the decoction. For the preparation of tobacco decoctions see under Preparation of Insecticides, below.

It might be advisable for one who has very much spraying to do to grow his own tobacco. Mr. W. S. Coburn, President of the Colorado State Board of Horticulture, tells us that he has had excellent success using tobacco of his own raising. He uses the whole leaf and makes a decoction using one pound of tobacco for each six gallons of water. The tobacco is steeped for at least one hour, and then applied warm.

Lime-Sulfur Sprays—The lime-sulfur sprays have not been successful in destroying the woolly aphis during the summer season when the body is covered with the woolly secretion. It has been fairly successful when applied two or three weeks before the buds open for the destruction of the little lice that live over winter upon the trees and which do not have their bodies protected by the secretion.

LATE WINTER OR EARLY SPRING APPLICATIONS

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphis were also largely freed from the woolly aphis. The insecticides that were found successful in the destruction of these little over-winter lice were:

Lime 15 pounds, sulfur 15 pounds, water 30 gallons.

Lime 15 pounds, sulfur 15 pounds, water 45 gallons.

Rex lime-sulfur 1 gal., water 7 gal., lump lime 2 lbs.

Lime 15 pounds, sulfur 15 pounds and water 60 gallons was a little weak and did not give results that were fully satisfactory, and the same was true of Rex 1 gallon, water 7 gallons, without the addition of lime.

We have no doubt but what the kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps mentioned above could also be used successfully as early spring sprays for the destruction of the over-winter lice upon the tree tops, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphis, and as the orchardist is likely to want to destroy both of these lice at the same time if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the woolly aphis the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then as a final act for best results, put Tanglefoot bands about the trunks of the

trees so that the lice at the roots can not migrate to the top. For the application of these bands see next paragraph.

TANGLEFOOT BANDS

In the experiments upon the Western Slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan and is the sticky material put upon the Tanglefoot Fly-Paper. When at all abundant upon the trees, the newly born lice are much inclined to travel about and it is often astonish to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Apparently these bands do no harm to trees, but what their effect might be when continued for years we are unable to say.* In most instances we have put them directly upon the bark but it would be safer, so far as any possible injury to the tree is concerned, to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band, in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphis.

MOUNDING AND CULTIVATING

The woolly aphis is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree but they get down to them directly from the surface above. So far as possible, the descending over-winter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration both to and from the roots can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compact after a rain or an irrigation.

TRIMMINGS

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths. A thorough thinning of the top so that plenty of sunlight can enter has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

---

*Mr. Geo. P. Weldon, reports, from recent observations upon the Western Slope in Colorado, rather severe injuries from the application of Tanglefoot bands that have been directly upon the bark for a year or more.

TREATMENT BELOW GROUND

The treatment below ground is all aimed at the lice that are within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below ground if they can only be put in contact with the lice, and then the orchardist should be cautious not to accumulate in the soil about the crowns of his trees substances that are likely either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY

A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given below.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following The materials used upon the roots were Kerosene Emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, whale-oil soap, and carbon bisulfid.

Before making the applications the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins which varied some in depth and diameter with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. And when the liquid had nearly or quite soaked into the ground the basin was filled again and the earth banked well about the trees. In hard compact soils it is best to irrigate a few days prior to making the treatment so as to loosen the soil, and lessen the labor of excavating about the trees.

Summing up the results to September, 1907, it may be said, that practically all strengths of kerosene emulsion (3% to 50%), killed the lice well when the roots had been well treated. Where less than 6% of oil was used, the odor of kerosene soon disappeared and reinfestation soon took place by the lice that migrated downward from the top. Where, 7, 10, and 15% of oil was used the effect was still more lasting; and the 20, 33 and 50% treatments gave practically perfect freedom from lice about the crown and roots throughout the season.

A later examination was made by Mr. George P. Weldon, 1908. Mr. Weldon found the woolly aphis about equally abundant upon the treated and untreated trees in all of the blocks. Even those that were treated with 50% kerosene emulsion were badly infested upon the roots at the time that he made his examination. So we have to conclude that any treatment for the destruction of the woolly aphis upon the roots is only of temporary value. But the stronger preparations do repel the lice for a short period of time, perhaps two or three months. Mr. Weldon also found that where the 50% emulsion was used the trees appeared to be seriously affected and

probably would not live through another year. None of the weaker preparations seem to have done any injury to the trees.

CONCLUSIONS AS TO BEST METHODS OF TREATMENT

Just before the buds open in the spring, spray very thoroughly with a 7% kerosene emulsion, a 1 to 60 Black Leaf Dip (or some other strong tobacco decoction), or a good whale-oil soap, 1-lb to 6 gallons of water. Spray the entire trunk and also the ground about the crown of the tree at the same time. Immediately after treatment apply a Tanglefoot band over cotton so as to prevent the upward migration. If the lice become very numerous at any time upon the tops, spray them forcefully with the 7% emulsion, or Black Leaf, 1 part in 70 parts of water.

Root treatments are temporary in their effects. When the roots become very badly infested, treat as above described with 10% kerosene emulsion, Black Leaf Dip (1 to 50), 2 to 3 gallons to a tree, or if the soil is quite open and porous, carbon bisulfid.*

CARBON BISULFID

This insecticide has often been reported successful against this insect.

A splendid opportunity was afforded to observe its results in the 20 acre orchard of Mr. F. D. Barney, where about 200 pounds of the liquid was used on 12-year-old apple trees. The treatment was begun on April 11, 1907, and was continued several weeks from this date.

A shovel was thrust deeply into the ground about 18 inches to two feet from the base of the tree with the blade broadcast to the tree. The handle was then tipped forward and the carbon bisulfid poured into the bottom and at the center of the opening at the back of the shovel. The shovel was then withdrawn and the earth packed upon the spot treated. The liquid was not poured directly upon the roots. From three to six holes were treated in this way about each tree and about three ounces of the liquid used. At this rate the cost of the material did not amount to as much as three cents per tree.

TOBACCO DUST AND STEMS

Dry tobacco in the form of tobacco dust or tobacco stems or even the whole leaf tobacco when used freely about the trees has not given very satisfactory results. Apparently these substances are of no use unless the tobacco is thoroughly wet, as soon as it has been placed about the roots, so that the juices will penetrate the soil and kill the lice. In a few instances orchardists have reported very satisfactory results but in nearly all cases they have reported failure. We believe if tobacco is used at all against this insect upon the roots of trees the best method is to apply it in the form of a strong decoction.

Prepare as for a top spray and use two or three gallons about each tree as in case of kerosene emulsion as described above. The tobacco does not have as lasting an effect apparently as does the emulsion.

---

*Carbon bisulfid may be procured in quantity from Edward R. Taylor, Penn Yan, New York.

Tobacco decoction in which two pounds of stems, or dust, or one pound of whole leaf tobacco was used to each three gallons of water and forcefully sprayed upon the exposed roots gave fairly good results but these were not equal in their killing and repelling effects to a 10 to 15% kerosene emulsion.

Black Leaf Dip used in the proportion of 1 gallon in 65 gallons of water gave results similar to the preceding.

Scalecide used 1 to 40, 1 to 50 and 1 to 60 in water killed the lice fairly well but had very little repelling effect afterwards.

Lump Lime applied in a manner similar to that employed with the tobacco stems, 10 to 20 pounds to a tree, was of little or no benefit.

Soaps used for root treatment were of doubtful benefit.

Some Wholly Unsuccessful Substances were, "Chloroleum" potash lye, wood ashes, salt, and flooding with water for several hours.

THE GREEN APPLE APHIS. (*Aphis pomi DeGeer.*)

This is the common green louse curling the leaves of the apple tree in Colorado. While primarially a leaf feeder this louse also attacks the tender tips of growing shoots, especially grafts and water sprouts. This insect ranks close to the woolly aphis in extent of injuries to the apple trees. It also attacks the pear, the thorn and the quince quite freely.

LIFE HISTORY

This louse remains upon the apple, or closely allied trees, throughout the year and does not go upon other trees or vegetables.

The first lice in the spring hatch from eggs that were deposited the previous fall upon the twigs of the trees. These first lice hatch a few days before the buds open and are ready to insert their sharp beaks into the first tender green tissue of the opening buds. These lice are all females and become fully grown in about two or three weeks, when they begin giving birth to living young. From this time on the lice increase very rapidly if they are not kept down by their natural enemies or the insecticides of the orchardist.

At first all the lice are wingless, but by the 10th to the 15th of May in the warmer portions of the state, and about two weeks later in the cooler orchard sections, the winged lice begin to appear and to fly from tree to tree and orchard to orchard with the prevailing winds. About the first week in September little brown wingless males and green wingless egg-laying females will appear, and a little later the females will begin laying green eggs that soon turn black upon the apple twigs. The freezing nights in November or early December kill all the lice and the eggs live over to hatch the following spring.

REMEDIES

Treatment for this insect may be for the destruction of the eggs and young lice before the buds open in the spring, or for the destruction of the lice upon the leaves during the growing season.

TO DESTROY THE EGGS

Kerosene Emulsion in all our experiments has proven useless

for the destruction of the eggs except when applied so strong as to make it entirely impractical to use it.

The Lime-Sulfur Mixtures—Either the 1-1-2, or the 1-1-3 formula or Rex lime-sulfur in dilutions down to 1 gallon in 8 gallons of water, have given good results. Lime-sulfur by the 1-1-4 formula is a little weak for good results.

Black Leaf—This preparation used in the proportion of 1 gallon in 25, and 1 gallon in 33 of water gave good results, but 1 gallon in 40 gallons of water was not very satisfactory, many of the eggs hatching.

SUMMER SPRAYING

For the destruction of the lice upon the leaves spray very thoroughly and forcefully from all directions with kerosene emulsion, 5 to 7 per cent. oil; Black Leaf, 1 part in 70 parts of water; or one of the other plant louse sprays discussed at the close of this bulletin, remembering that thorough and forceful applications are necessary in order to get best results.

PEACH PLANT LICE.

There are two species of plant lice attacking peach trees in Colorado, the Green Peach Aphis (*Myzus persicæ Sulz.*) and the Black Peach Aphis (*Aphis persicae-niger Smith.*) The former is very generally distributed and occurs nearly every where that this fruit is grown, while the latter occurs in isolated orchards only, and might be kept down so as to do no appreciable harm, and it is quite possible that it might be practical to exterminate it from the state.

THE GREEN PEACH APHIS

Is distinguished by its pale green, or greenish yellow color in the wingless forms and the winged lice have the same general ground color to their bodies with more or less of black markings above.

The lice appear very early in the spring and often attack the blossoms, and the young peaches when the latter first form, causing them to wilt and drop. Later it attacks the leaves causing them to curl and turn yellow. By the middle of the summer this louse leaves the peach trees and goes to cabbages, turnips, radishes, tomatoes, potatoes and many other growing crops, as well as many of the common weeds. The lice remain upon these plants during the summer and in the fall there are winged forms that return to the peach to give birth to true males and females, the latter of which deposit the eggs that remain upon the twigs of the trees during winter to hatch out the early lice of the following spring.

REMEDIES

Spray thoroughly with kerosene emulsion, Black Leaf (1 part in 60 of water), or a solution of whale-oil soap (1 pound to 6 gallons of water), about three or four days before the blossoms open. Then, if the lice appear later, treat as in case of the green apple aphis.

THE BLACK PEACH APHIS

This louse is readily distinguished from any other attacking the peach

by its black color when fully grown, whether winged or wingless. The immature lice are of a yellow or amber color. In all stages, and especially in the spring, this louse will be found upon the bark of the small limbs where it continues to feed after the leaves appear. Many of the lice will go upon the leaves also causing them to curl.

Like the preceding species, this louse also disappears by the middle of July or the first of August without anything being done for it, but it does not go to any other plants so far as known, but is said to descend to the roots of the peach where it remains until the following spring. So far as known this species does not lay eggs but lives over winter as a louse.

This insect is continually being shipped into Colorado upon the roots of nursery stock. Our Horticultural law and the vigilence of our county horticultural inspectors has done much to keep it out of the orchards, but it is impossible, under present methods, to prevent an occasional tree, infested with this louse, being planted.

REMEDIES

All peach trees, before being planted, should be thoroughly fumigated, or dipped or sprayed with Black Leaf, a home-made tobacco decoction, or a good kerosene emulsion.

The remedies in the orchard are the same as for the Green Peach Aphis mentioned above.

PLUM PLANT LICE.

THE MEALY PLUM LOUSE. (*Hyalopterus arundinis Fab.*)

A light green louse with a rather long narrow body that is covered with a fine white powder. The lice occur upon the under side of the leaves, which they may completely cover by the middle of June, but the leaves do not curl. By the first week in July, many of the lice are winged, and by the last of that month the lice will nearly all have left the plum. The lice go to certain grasses, especially the large coarse Reed-grass growing in wet places. In the fall winged migrants return to the plum where, later, the eggs are deposited by egg-laying females and the lice all die. The next spring the eggs hatch to continue the species.

REMEDIES

Spray as for the green peach aphis but use a heavy pressure and direct all of the spray upon the under side of the leaves where all the lice are. These lice are killed with difficulty on account of the powdery covering upon their bodies.

THE RUSTY PLUM LOUSE. (*Aphis setariae Thos.*)

This louse is readily distinguished from all others upon the plum by its dark brown body color, and with a hand lens one can usually see the conspicuous white legs, antennae and tail. This louse seems to have a preference for the tender bark near the tips of rapidly growing shoots although it covers the undersides of the leaves also. At a little distance the louse may almost appear black to the naked eye. This louse spends the entire

year upon the plum, though it is known to attack barn grass **Echinochloa Crus-galli.**

The remedies for this louse are exactly the same as for the green peach aphis already mentioned.

THE BLACK CHERRY LOUSE. (*Myzus cerasi Fab.*)

This louse has long been known in Europe as a pest upon cherry trees. It is generally distributed throughout the cherry growing districts of the eastern slope in Colorado, but as yet only occurs in isolated orchards upon the western slope.

Those having cherry trees should make a vigorous attempt to exterminate this louse as soon as it is noticed in the cherry orchards. It could not be mistaken for any other insect upon the cherry tree as it is deep black in color and infests the under side of the leaves and the bark of the tender new growth. It is usually accompanied by ants in abundance. This insect remains upon the cherry, and so far as known, does not migrate to any other plant. On account of its numerous insect enemies it is likely to almost disappear for a time during the middle of the summer, but may continue quite abundant thoroughout the season. The last brood in the fall lay eggs which carry the species over winter to hatch in the spring.

The remedies are exactly the same as for the foregoing species.

THE HOP PLANT LOUSE. (*Phorodon humuli.*)

This is the green louse that has caused such severe losses in hop vineyards. The hop is the summer food-plant and in the fall winged hop lice migrate to the plum trees where the egg-laying females later deposite eggs upon the branches which hatch the following spring. These lice are very similar to the preceding in general appearance but lack the heavy covering of powder. While most of the lice leave the trees for the hop before the middle of July, we have found some of the lice remaining throughout the summer on plum leaves.

REMEDIES

The same as for the green peach aphis.

PREPARATION OF A FEW IMPORTANT PLANT LOUSE INSECTICIDES

Kerosene Emulsion—Prepare in the following proportions:

Soap one half pound.
Water one gallon.
Kerosene two gallons.

To prepare, dissolve one half pound of soap in one gallon of soft water by boiling; when well dissolved and still boiling hot, remove from the fire and add two gallons of kerosene, and agitate at once as briskly as possible. If large quantities are being made, a good way to emulsify is to use a force pump and spraying nozzel and pump the mixture as forcefully as possible back into the vessel containing it. If the emulsion is properly formed, the whole mass will appear much like whipped cream and will mix readilly in water without a film of oil rising to the top. Sometimes, when

the oil is rather cold, it lowers the temperature so much that a good emulsion is not obtained. In this case the dish may be placed back over the fire and the mixture heated to the boiling point when it must be again removed and agitated to form the emulsion. In case the mixture of soapy water and kerosene is placed over the fire, it must be watched every moment to see that it does not quickly boil over and take fire. As soon as emulsified, add twenty-seven gallons of water and use at once. This will make thirty gallons of the mixture, and such an emulsion will be one-fifteenth oil (or a 7% emulsion). This is the strength ordinarily used for the destruction of insects upon plants. For larger or smaller quantities, prepare in the same proportions.

Sometimes the emulsion is not perfect and a little oil rises to the top. In such cases, if the last in the barrel or tank is pumped out upon the foliage, it is likely to burn it. So it is advisable, unless the emulsion is of good quality, to throw out the last few gallons making no use of it.

It is best to dilute and apply kerosene emulsion as soon as it is prepared.

Avoid using alkali or any hard water in making the emulsion, as it will cause the oil to separate and rise to the top. Any clean soft water will usually give good results.

If a stronger emulsion is to be used, prepare as above, but do not use as much water in making the dilution. For example, if 17 gallons of water were added in place of 27 to dilute the emulsion, it would be one-tenth oil or a ten per cent. emulsion, and if 37 gallons were added, it would be a five per cent. emulsion.

Those who have trouble in making kerosene emulsion can procure a commercial article known as "Aphiscide" manufactured at Grand Junction, or else use one of the tobacco preparations instead.

Tobacco Decoction—

Tobacco stems or tobacco dust two pounds.
Water four gallons.

Put the tobacco in the water, enought to cover, which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simply simmer for fully one hour, when the liquid is ready to be drained off, diluted to the above proportions and applied.*

If whole-leaf tobacco is used, prepare as above using one pound of tobacco to each four gallons of water.

No lime or other alkaline substances should be added to the tobacco while cooking. Apply at once, or within a few days after making if possible.

Black Leaf—There is nothing to do in the preparation of Black Leaf except to thoroughly stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the Black Leaf will be found sufficient for each seventy gallons of water. But if in the treatment of any louse this does not seem sufficient it may be used in proportion

*Dr. W. P. Headden, Chemist of the Experiment Station, has proven that the nicotine is rapidly driven off by boiling, and especially where the water is strongly alkaline.

of one gallon to sixty or sixty-five gallons of water. We have usually succeeded in killing plant lice with this preparation in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

If this substance is not obtainable in your home town it may be procured from the Watkins Merchandise Co., Denver, or The Kentucky Tobacco Product Co., Louisville, Kentucky.

Miscible Oils—There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," or "Target Brand Scale Destroyer" or "Killoscale," add the oil directly to the water with a little stirring. One gallon of the miscible oil in 30 to 50 gallons of water will make a mixture, which in most cases will be strong enough to kill plant lice, if thoroughly applied.

Lime-Sulfur Mixture—(For winter spray only.)

Flowers of sulfur, fifteen pounds.
Good lump lime, fifteen pounds.
Water, forty-five gallons.

This is the 1-1-3 lime-sulfur mixture. First slake the lump lime with sufficient warm water, and while still boiling hot add the sulfur and stir it in. Place over fire and continue the boiling, adding water when necessary, until the mixture changes to a deep reddish brown color which indicates that the lime has cut the sulfur. It will be necessary to boil steadily for about forty minutes to one hour to produce this result. The mixture should then be diluted to form forty-five gallons of the spray, and should be applied at once.

When the lime-sulfur mixture is placed in the barrel or tank it should be strained to take out all lumps that would clog the spray nozzle. If allowed to stand for any great length of time after being prepared, the lime-sulfur crystalizes out to a considerable extent. In such a case it is necessary to heat the mixture again before applying so as to dissolve all the crystals. If the crystals are re-dissolved the mixture will be as strong as before.

To make 1-1-2 lime sulfur mixture, prepare as above using only thirty gallons of water for the fifteen pounds of lime and the fifteen pounds of sulfur.

For the 1-1-4 lime-sulfur mixture prepare in the same manner, but dilute to sixty gallons before applying.

Rex Lime-Sulfur—We have found the Rex lime-sulfur in the proportion of one gallon of the Rex to seven or eight gallons of water to be just about equal in effect to the 1-1-3 home made lime-sulfur preparation. Rex lime-sulfur solution can be made white by the addition of lime at the rate of 5 to 10 pounds for each 50 gallons of spray.

Whale-Oil or Fish-Oil Soaps—The so-called whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice, will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six to eight gallons of water. There are numerous brands of these soaps upon the market. Those that we have used quite successfully are Good's Whale-Oil Soap and Bowker's Tree Soap.

Bulletin 135 December 1908

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE AUSTRALIAN SALTBUSH

Its Composition and Digestibility

NOTES ON RUSSIAN THISTLE

BY

WM. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
Hon. J. L. CHATFIELD,	Gypsum,	1909
Hon. B. U. DYE,	Rocky Ford,	1909
Hon. B. F. ROCKAFELLOW, President,	Canon City,	1911
Hon. E. H. GRUBB,	Carbondale,	1911
Hon. R. W. CORWIN,	Pueblo,	1913
Hon. A. A. EDWARDS,	Fort Collins,	1913
Hon. F. E. BROOKS,	Colorado Springs,	1915
Hon. J. L. BRUSH,	Greeley,	1915

Governor HENRY A. BUCHTEL,
President BARTON O. AYLESWORTH, } *Ex-Officio.*

A. M. HAWLEY, Secretary — CHARLES SHELDON, Treasurer

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. — B. U. DYE.

STATION STAFF

L. G. CARPENTER, M. S., *Director*, — Irrigation Engineer
C. P. GILLETTE, M. S., — Entomologist
W. P. HEADDEN, A. M., Ph. D., — Chemist
WENDELL PADDOCK, M. S., — Horticulturist
G. H. GLOVER, M. S., D. V. M., — Veterinarian
CARL W. GAY, B. S., D. V. S. — Horse Breeding
ALVIN W. KEYSER, A. M. — Agronomist
W. G. SACKETT, B. S., — Bacteriologist
R. E. TRIMBLE, B. S., — Assistant Irrigation Engineer
F. C. ALFORD, M. S., — Assistant Chemist
EARL DOUGLASS, M. S., — Assistant Chemist
S. ARTHUR JOHNSON, M. S., — Assistant Entomologist
B. O. LONGYEAR, B. S., — Assistant Horticulturist
E. B. HOUSE, M. S., — Assistant Irrigation Engineer
F. KNORR, B. S., — Assistant Agronomist
P. K. BLINN, B. S., — Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S., — Potato Investigations
MIRIAM A. PALMER, — Artist
L. C. BRAGG, — Ass't in Entomology

State Fruit Investigations

O. B. WHIPPLE, B. S., Grand Junction, — Field Horticulturist
GEORGE P. WELDON, B. S., Delta — Field Entomologist

OFFICERS

President BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S., — Director
A. M. HAWLEY, — Secretary
MARGARET MURRAY, — Clerk

AUSTRALIAN SALTBUSH (*Atriplex semibaccata*)

ITS COMPOSITION AND DIGESTIBILITY

NOTES ON RUSSIAN THISTLE

By WM. P. HEADDEN

The California Experiment Station received the seed of this saltbush from Baron Von Mueller in 1888. In 1899, Charles H. Shinn, in Bulletin 125, states as the result of eighteen years' experimentation with saltbushes at that station, "that the *Atriplex semibaccata,* is the most generally useful species of all that have been planted, although others are worthy of cultivation."

Very favorable reports concerning the value of this plant gained currency, and it seemed that it might be of value to Colorado, as it would furnish a desirable fodder for the stock in the eastern part of the State, where the rainfall is sometimes insufficient for the production of good corps of other forage plants. This view was entertained by the writer previous to the appearance of the bulletin above referred to and seemed to be confirmed by the facts set forth therein. A small quantity of seed was procured in the spring of 1900 and planted on land previously used for experiments with sugar beets. The seeds were drilled in very shallow, but still too deep according to subsequent experience and a very poor stand was obtained—except in spots, where the plants were too thick.

The growth of the plants was entirely satisfactory, some of them attaining a diameter of seven feet and they bore an abundance of seed. I left the plot till the next spring, hoping to learn whether the seed would germinate and furnish me plants enough for the work of the ensuing year. In the meantime, however, a change had been made in the chair of agriculture and the new incumbent, knowing nothing about my work, plowed up my plot. This will explain why some of the statements in this account of the plant in Colorado are based on a garden experiment.

So far as the general culture of the plant is concerned the only question that presents any trouble is in getting it established; when once established it will seed itself abundantly. The best way to obtain a stand of this plant, in the beginning at least, is by transplanting; one can, of course, drill the seed. If this is done, the drills should be at least eight feet apart. The young plants, if well hardened and stocky, will need a little water when first set out to start them well, but when once established they will stand neglect, drought, and more abuse than most plants.

The seed, if they are plump, and fairly fresh, will germinate freely, but will rot if covered deeply. If they are sown in boxes, it is best to firm them and scarcely cover them at all. Good results

may be obtained by simply firming the seed on the soil and covering for a day or two with a thin cloth of any sort which can be kept moist. A similar observation concerning the depth of sowing is made by the California Station in Bulletin 125.

The first season's experience with this plant was on a poorly drained, alkali soil, and while for reasons already given, the experiment was not as satisfactory as one might wish, the results sufficed to show that the plant will do well under such conditions and furnish a large amount of fodder. Some of the single plants attained a diameter of seven feet. The garden experiment was in the main more successful, though less attention was paid to it. The plants seeded heavily and were not gathered, but left where they grew. They proved to be easily killed by freezing—it is stated in the California bulletin that the plants will endure a temperature of 14° F. below the freezing point.

My plants in the garden plot all perished during the winter, but the seed came up very freely the following spring, and this little plantation maintained itself for the next five seasons with but little care and without other water than our usual rainfall.

The California station made observations on the amount of rainfall necessary for this plant to make some growth, not a luxuriant growth whereby single plants attain a diameter of twelve or more feet, but sufficient when planted in rows two feet apart to cover the ground. They state that "one-fifth of an acre, sown in December, yielded 100 pounds of seed. This plot was cut in September and, cured for fodder, yielded at the rate of five and one-half tons of hay per acre. Three such cuttings were practicable on this light, granitic, sandy loam, underlaid by hard pan, during the driest season known." The rainfall for this season, 1897-'98, is given as 4.75 inches. The plant makes a remarkable growth with a very small supply of water. The writer of the bulletin referred to states further that, "on unirrigated land there was no green fodder-plant excepting saltbush (*A. semibaccata*), in the entire region." The rainfall during the seasons that the plant grew in my garden without irrigation was not noted, and while it was certainly larger than this recorded at one of the California sub-stations, it was not sufficient for the growth of our ordinary grasses.

This plant grows on the ground, not erect like alfalfa, but spreads out into a circular mass varying in diameter. Well-grown individual plants in our plot attained a diameter of seven feet, but single plants are recorded as having attained, in California, a diameter of even eighteen feet. The stems are slender and leafy.

The habit of the plant makes it hard to cut, and the leaves are easily lost in making hay—this plant is, of course, not to be considered as a forage plant where alfalfa can be grown—but its drought

resisting power may make it worthy of consideration by some people in this State. In our eastern counties, I have seen Russian thistle hay and have been informed that it was highly prized. I took this statement *cum grano salis* because the hay did not look to me as though it were fit to be eaten by any kind of stock and I saw no proof that the stock liked it. Mr. Payne, of Akron, suggests that Russian thistle hay may have a place in the feed of the plains stock as a laxative, for constipation is not uncommon among them. The Russian thistle is used to a limited extent in other parts of the State for hay making, and inquiry elicited from a thrifty, energetic ranchman the information that he had found it entirely unsatisfactory. Further, I have known the saltbush, *A. argentea,* to have been made into hay not for constant use, but as an emergency fodder for periods when the stock could not obtain enough to eat, or indeed anything by grazing. In sections where forage plants are such a desideratum as in these just referred to, any plant having better qualities than the indigenous ones or such as have been imported would be a blessing. This is really the reason for presenting this bulletin, for in this Australian saltbush, *A. semibaccata,* we have a plant which will reproduce itself freely from seed; the little plants will bear transplanting quite well; it will resist drought after it is well rooted and produce an amount of hay greater than the thistle now occasionally used, and of certainly as good or a better quality. In the sections of the country to which reference has been made small crops of sorghum can be grown, not always enough to be called a crop, but sometimes a fair one. This sorghum is not, especially in the spring of the year, a good fodder. It has no spines, as the thistle hay has, but sheep fed on it—sorghum fodder—lost weight rapidly. I know nothing about either the yield or quality of milo maize, but as compared with the other fodders mentioned, the Australian saltbush hay, though not presenting an attractive appearance, is worthy of consideration and that not as a portion of a ration but as a fodder to be given alone, for the question presenting itself to those persons in Colorado who may find it to their advantage to grow this as a forage plant, will in all probability be, not what they may mix to produce an advantageous ration, but simply as to what they can obtain to feed. The fact that they have used the so-called sand grass of the plains, Russian thistle, sunflower, and the native saltbush, *Atriplex argentea,* for the purpose of hay making indicates clearly that anything as good or better than the best of these, which they can grow, is at least a desirable thing for them.

The study of this plant had another object in view, or perhaps it is more nearly correct to state that in the beginning the object was to study its merits as a fodder and its adaptability to Colorado conditions, but in the end the object was extended to what we may

more properly designate as a chemical study of the fodder. It was advisable then from either standpoint to study the effects of the hay when fed alone, and it is not intended that any statement made shall be construed as indicating that hay made from this plant might not give more satisfactory results than will be presented in this bulletin if properly mixed with some other fodder but, as already stated, the conditions under which it would have to be fed have alone been considered.

So far as the readiness with which this saltbush can be grown is concerned and its ability to make a good growth with a small supply of water it commends itself. The other questions pertaining to it may be succinctly stated in a few words, does it present difficulties in cutting and being made into hay, will animals eat it readily and do they do well on it, *i. e.*, does it furnish sufficient nourishment to maintain or perhaps fatten the animals?

Under our conditions the plant is an annual which forms a spreading mass of growth on the ground, unless planted very thick, as it is apt to be in the case of self-seeding, when it might be feasible to mow it and handle it as we handle alfalfa in hay making. If, however, the plants are single it would seem necessary to adopt some other system of gathering it, probably the best method would be to turn up one side of the row and cut off the root with a chisel-like instrument. It would have to be handled as green as possible as, when dry, the leaves drop off badly.

The statement is made that animals eat it readily. To again quote the California Bulletin 125, p. 8: "At Tulare sub-station saltbush was fed to sheep, cattle, horses and hogs. With sheep the ration was increased until some received nearly their whole sustenance for months at a time from this plant, keeping in excellent condition, and being turned off to the butcher as 'fat mutton' without any other food except a little straw."

Other testimony on this point given on the same page, but by correspondents, is by no means so favorable, for some say "stock won't eat it." All shades of opinion between these two extremes seem to have been expressed by the correspondents in regard to the readiness with which it is eaten. On page 26 of the same bulletin, Prof. Jaffa states: "It is not advisable to feed the saltbush alone, particularly in the air-dried state, owing to the high percentage of the saline ingredients, and the general uninviting appearance and condition of the saltbush hay. In cases of emergency, however, sheep and cattle have existed altogether on this material through an entire season." These quoted statements, at least some of them, are general statements which contemplate other saltbushes as well as the *A. semibaccata,* which is the one had in mind in this bulletin.

We have fed it both green and dried, but almost exclusively to sheep. In one experiment we fed it to a horse. When fed green we had no trouble in inducing a lot of three sheep to eat it. The horse had been pasturing on it to some extent before we began feeding it to him as his only fodder. The sheep were fully matured animals in good condition; the weather during the time of the experiment, as well as all other conditions under which it was made, were altogether favorable. The time of feeding between weighings was three weeks. The result was that the lot had neither gained nor lost. The horse was not weighed, but we assumed that he had not lost materially, if at all; he ate the green fodder readily. At first the sheep showed the laxative qualities of the saltbush to a slight etxent, but this was of short duration and was at no time serious; the horse also showed it at first, but in this case it was also of short duration. There is doubtlessly a difference in individual animals in regard to the effects of this as well as any other fodder and it may be of a little interest to some to know that of the three sheep fed in this experiment, one gained a pound, one lost a pound, and the third just maintained its weight.

The green fodder was not analyzed, nor was there any account taken of the amount of the green fodder eaten; the only care taken was that they should have as much of the fresh fodder as they would eat. Samples of hay, however, were prepared from plants taken from different portions of the plot, as it varied considerably in the character of its soil. This feature of the experiment will not be mentioned further, but it is probably the cause of the very considerable variations shown in the analyses of these samples.

The plot of ground on which the saltbush grew was in parts as strongly alkalized as any of which I had knowledge and was poorly drained, still we had previously grown sugar beets on the plot and obtained a yield of 19 tons to the acre and the beets were of excellent quality. Some portions of the plot, too, had been manured, so that it is quite right that the samples of saltbush hay should vary somewhat in their composition if these things have any influence on the composition of growing plants.

As to the amount of hay we would be justified in expecting to obtain from an acre, I can give no opinion, as no data on this point was obtained.

I have grown some of this plant for the past eight seasons, but at no time since the first season have I had it on a measured plot, and the first season I obtained nothing like a good stand. On this point I will again quote Bulletin 125 of the California Station: "In February, 1896, saltbush seed was drilled here on the surface, in rows eight feet apart, and by September, when visited, the surface

was nearly covered. A part of the crop was cut twice, yielding at the rate of four tons of hay per acre." This is a very modest yield compared with those indicated by some of the correspondents, which would figure out at least one-half more. This may all be interpreted when applied to our conditions that the saltbush may be expected to yield a large crop of hay per acre provided the stand is good.

The composition of the crop of 1900 is given in the following table:

COMPOSITION OF SALTBUSH (*A. semibaccata*) HAY.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Sample 1	6.16	17.90	1.18	13.21	23.79	37.76
Sample 2	7.94	19.48	1.09	13.70	24.34	33.45
Sample 3	8.34	17.02	1.17	9.41	28.31	35.75
Sample 4	8.45	15.07	1.12	8.70	28.00	38.66

For the leaves and stems we obtained the following:

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Leaves	6.42	24.29	1.66	15.92	8.99	42.72
Stems	5.25	8.75	0.72	6.46	44.67	34.15

The ratio of leaves to stems in a sample grown in 1906, which we may assume to be representative, was 8.6 to 6.5, or in round numbers, 60 per cent. leaves and 40 per cent. stems, according to which an average hay should contain about 12.2 per cent. proteids based on the analyses of leaves and stems given above, but the average percentage of protein indicated by the analyses of the four samples of hay is 11.26 per cent. This average is probably too low, owing to the low percentage of this constituent in samples three and four, both of which contain about or even less than one-half the amount of proteids found in later samples.

The four analyses, as previously indicated, serve to show how this hay may vary in quality even from the same field when no other condition than the variation in soil conditions can be appealed to as suggesting a plausible explanation; this is apparently a sufficient cause for the lack of uniformity in the published analyses of this hay, which is evident from the following, which are all of such analyses that I have been able to find:

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Arizona Rep. 1903	6.30	17.90	2.11	14.13	20.75	38.81
California Bulletin 125	7.05	19.37	2.01	11.64	15.88	44.05
California Bulletin 125	10.00	17.74	1.47	14.14	20.18	36.54
South Dakota Bul. 69	7.40	13.09	2.05	18.87	25.97	32.62

In our analyses of the samples grown in 1900, we notice a variation of five per cent. in the protein content, but an extreme of

seven per cent. in the four analyses above quoted. In other samples which will be described later we will find that this hay may contain even a higher percentage of protein than is shown by the South Dakota sample.

A little over two years ago I thought the time opportune to publish these observations on the probable value of this saltbush, especially to those sections of the State where the rainfall is usually too scant to grow good crops of other forage, but on looking up the literature there seemed to be so little positively established, particularly concerning its digestibility and feeding value, that it seemed wise to defer publishing them until additional data relative to these points had become available. We, therefore, began anew and grew another crop of the saltbush and determined its coefficients of digestion, using three sheep, wethers going on two years old, for this purpose.

This crop was started by raising the seedlings in boxes and transplanting them, but owing to a number of things, over which I had no control, it was very late in June before the seedlings were transplanted to the plot set aside for this experiment. The soil was of good quality and in good condition and free from alkali, and the water used for irrigation was likewise free from these salts. The plants grew very well and seeded abundantly, though set out so late in the season. We had no intention of trying to establish the minimum length of the season sufficient to grow a fair crop of this hay, but the accidents happening to this experiment show that if the plants get a good start by July 1st they will do well in this portion of the State. This crop was gathered and cured on sheets under the direction of Mr. F. Knorr, assistant in Agronomy, so that we had the whole plant, leaves and stems, to feed.

The sheep were taken from fattening pens, where they had been receiving a full feed of alfalfa hay and some grain. They at first received alfalfa hay alone, then alfalfa and saltbush hay, the latter being gradually increased till they received saltbush alone, when the preliminary period of the feeding began. The sheep had in the meantime become somewhat accustomed to being handled and also to their harness. The sheep did not seem to really like this hay, one in particular, sheep No. 1, continued to protest against it, but in the end the experiment proceeded quite satisfactorily. In the preceding experiment it will be recalled that we had sheep at last three years old. They were accustomed to the person feeding them, to the pens in which they were fed, and wore no harness to annoy them and were not handled. The result of feeding them green saltbush, a period of three weeks elapsing between weighings, was that the lot just maintained its weight with a variation of only one pound in any sheep. The fodder was green and more inviting

than the hay, and all of the conditions under which the experiment was conducted were favorable. In this second experiment we also used three sheep, young ones, and made them just as comfortable as possible, and again the results indicate that this hay fed alone will simply maintain the weight of the lot. In this case sheep No. 1 gained ¼ of a pound; sheep No. 2 gained ¾ of a pound, and sheep No. 3 lost ¼ of a pound. The total weight at the beginning of the feeding period was 243.25 pounds, at the end of the period 244.0 pounds, a gain of three-quarters of a pound. It was rather surprising that sheep No. 1 should show any gain, for the animal evidently did not like the hay and ate much less of it than the others, about two-fifths only of the average of the other two sheep. I will not go into the details of this case, but do not think that it should be included in averaging the results. The only good purpose that it serves is to show how very different the results with some individual animals may be from the average, and further to emphasize the fact that some individual animals do not take kindly to this fodder. Though the general tenor of the statements regarding this point would lead me to infer that sheep take to it better than other animals. The composition of this hay, made from quickly grown plants, the feeding data, composition of the feces and the coefficients of digestion are given below:

COMPOSITION OF THE SALTBUSH HAY, ORTS, AND FECES.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	3.645	18.635	1.370	20.600	16.382	39.368
Orts—						
Sheep No. 1	3.610	21.668	1.460	20.820	15.233	37.209
Sheep No. 2	3.595	24.251	1.400	20.310	13.287	37.157
Sheep No. 3	3.485	22.156	1.400	20.500	14.502	37.957
Feces—						
Sheep No. 1	4.560	14.974	2.350	7.940	35.417	34.759
Sheep No. 2	4.525	15.894	2.240	8.090	32.142	37.109
Sheep No. 3	4.820	17.848	2.880	7.750	31.205	35.497

Experimental Data—Sheep No. 1 received 6,577 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	6337.27	1225.62	90.11	1354.86	1077.44	2589.24
Orts	4192.00	942.34	63.50	905.46	662.48	1618.22
Consumed	2145.27	283.28	26.61	449.40	414.96	871.02
Voided	1089.93	171.03	26.83	90.67	404.46	396.94
Digested	1055.34	112.25	-0.22	358.73	10.50	574.08
Coefficients of Digestion	49.19	39.57	.....	79.74	2.53	58.85

This animal weighed at the beginning of the experiment 78¼

pounds, and at the end 78½ pounds.

Sheep No. 2 received 7,938 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	7648.66	1479.30	108.76	1635.20	1300.40	3125.00
Orts	2056.32	517.28	29:86	433.21	283.41	792.56
Consumed	5592.34	962.02	78.90	1201.99	1016.99	2332.44
Voided	2195.93	365.57	51.52	186.07	739.26	853.51
Digested	3396.41	596.45	27.38	1015.92	277.73	1478.93
Coefficients of Digestion	**60.87**	**62.00**	**34.70**	**84.52**	**27.31**	**63.41**

This sheep weighed at the beginning of the experiment 79¼ pounds, and at the end 80 pounds.

Sheep No. 3 received 7,938 grams of hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Hay	7648.66	1479.30	108.76	1635.20	1300.40	3125.00
Orts	2565.37	588.91	37.21	544.89	385.45	1008.89
Consumed	5083.29	890.39	71.55	1090.31	914.95	2116.11
Voided	2028.29	380.34	61.37	165.94	664.98	755.66
Digested	3055.00	501.05	10.18	924.37	249.97	1360.45
Coefficients of Digestion	**60.10**	**57.28**	**14.23**	**84.78**	**27.29**	**64.29**

This animal weighed at the beginning of the experiment 85.75, at the end 85.5 pounds.

The average coefficients of digestion for sheep Nos. 2 and 3 are, for the dry matter, 60.48; ash, 59.64; fat, 24.46; protein, 84.65; crude fibre, 27.30, and for the nitrogen free extract, 63.83.

The deportment of sheep No. 1 and the data showing the results obtained with this animal do not justify the inclusion of these results in stating the average coefficients found. We notice that the animal consumed only 2,145.27 grams of dry matter and digested 1,055.34 grams in five days and still maintained its weight or a little better, as it gained one-quarter of a pound. This animal was a light eater, even of alfalfa. In addition to these facts the coefficients of digestion are altogether too low in comparison with those found for the other sheep and can simply serve to show that the protein and nitrogen free extract have high coefficients of digestion, while the crude fibre is very difficultly digestible.

A comparison of these coefficients with some of our well known fodders may be of some service. The coefficients for alfalfa, timothy and native hay have been taken from Bulletin 93 of this Station. Those given for the oat hay are averages taken from Bulletin 77, p. 20, U. S. Department of Agriculture.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Alfalfa	62.05	57.67	29.86	72.54	49.93	72.89
Timothy hay	51.03	65.63	69.32	43.35	36.08	54.99
Native hay	50.53	42.52	20.55	62.33	55.56	51.30
Oat hay, average....	49.30	34.60	54.20	43.50	52.00	61.90
Saltbush hay (A. semibaccata)..	60.48	59.64	24.46	84.65	27.30	63.83

It will be observed that the composition of the saltbush compares very favorably with that of our best fodders. The proteids are high, especially in the South Dakota sample and the one used in our digestion experiments, 18.87 per cent. in the former and 20.60 per cent. in the latter. While the nitrogen free extract is lower than in the hay made from grasses it is quite as high as in the leguminous hays, alfalfa, or pea-vine hay. The crude fibre is low and the ash exceptionally high. The proteids present are not only high in percentage, but they also have a very high coefficient of digestion—84.65—which is, I believe, a higher coefficient than has been found for the proteids in any other hay and which has been approached in the case of but few hays. The ash is present in large quantities and is highly digestible, as one would expect, because it consists very largely of alkali salts. No apparent inconvenience was caused the sheep by the ingestion of these large amounts of ash constituents, except in the early part of our first feeding experiment, when the saltbush was fed green, but in this case the trouble was of short duration and did not recur. The crude fibre is not very abundant and has a low coefficient of digestion.

In spite of all of these good points the results of our two experiments with sheep indicate that the saltbush, when fed alone, will just maintain the animal. The results were the same whether it was fed green or in the form of hay. The leaves are not greedily eaten by the sheep; perhaps the very large amount of ash constituents present in them has something to do with this. There would seem to be no question but that in order to get the best effects out of a fodder containing 20 per cent. of protein it should be mixed with another poorer in nitrogenous substances.

This plant is supposed to grow particularly well on alkali soils. I found that it does well on soils which are considered as free from alkali, but remarkable differences seem to exist in the composition of the plant and also in that of the ash. The samples 1 to 4 inclusive were gathered from the same plot of ground; the soil varied, and we find that the proteid content varies by five per cent. Again, one of the California samples contained 11.64 per cent., while the South Dakota sample carried 18.87 per cent., and our last sample used in the digestion experiment contained 20.60 per cent., an extreme difference of 11.90 per cent., which, I believe, to indicate

the ability of this plant, to vary in composition according to the soil conditions under which it may be grown. Climate has nothing or very little to do with this case, as two of the samples referred to were grown at this Station.

The high content of mineral matter—ash—leads directly to the inference that the plant makes a heavy draft on the soil, especially as the plant is not only rich in ash but also yields a heavy crop. The California Experiment Station cut at the rate of 5½ tons of hay per acre, (Cali. Ex. Sta. Bul. 125, p. 6.); others give a much larger crop (ibib. p. 7), where a green crop is given as approximately 30 tons, which would not be less than 6.5 to 7 tons of hay. The hay made from this saltbush carries about 17 per cent. of ash, the sand and dust deducted. This would mean the removal of from 900 to 1,200 pounds of lime, magnesia, potash and soda from each acre of land, of which, according to my analyses, from 288 to 384 pounds would be potash and from 252 to 336 pounds would be soda. There would further be removed from 64 to 83 pounds of phosphoric acid.

These facts are of interest principally to show that the plant is a very heavy feeder, more so indeed than most useful plants. While alfalfa is a heavy feeder, removing from 180 to 200 pounds of mineral matter with each ton of hay, it is far behind the saltbush in this respect, which will remove not far from 340 pounds with each ton of hay. This matter is of little interest so far as this bulletin is concerned, still it may be worth while to consider the composition of the ash of this saltbush.

ANALYSES OF THE ASH OF THE AUSTRALIAN SALTBUSH, *Atriplex semibaccata.*

	Alkali Soil.	Alkali Free Soil.	Alkali Soil.*
Carbon	Trace	Trace	
Sand	3.82	10.93	
Silicic acid	1.24	4.60	16.24
Sulfuric acid	3.46	2.14	2.64
Carbonic acid	16.88	21.51	....
Phosphoric acid	3.54	3.43	2.80
Chlorin	20.80	5.82	24.33
Potassic oxid	14.37	16.02	11.42
Sodic oxid	23.79	14.85	35.39
Calcic oxid (lime)	8.54	13.27	5.79
Magnesic oxid	6.94	6.20	3.23
Ferric oxid	1.23	0.90	1.38
Aluminic oxid	Trace	1.21	1.95
Aluminic oxid	Trace	1.21	1.95
	104.75	100.99	105.39
Oxygen equivalent to chlorin	4.69	1.31	5.35
	100.06	99.68	100.04

*California Bulletin 105, p. 13.

The most striking differences are shown in the chlorin content. The California sample shows that almost one-fourth of the ash is represented by chlorin, while our sample, grown upon good, upland soil, considered free from alkali, shows that this element—chlorin—makes up only one-sixteenth of the ash. Again, the California sample shows three times as much soda as potash, while our upland sample shows more potash than soda. It is further clear at a glance that our sample grown on alkali soil approaches much more nearly to the composition of the California sample.

The plant takes up under the conditions of alkali soils a large amount of salt. The data given in the California bulletin show that it takes up, in round numbers, 800 pounds of salt, sodic chlorid, in producing five tons of hay. Our data show that it used about 600 when grown on alkali soil and only 163 pounds when grown on good, non-alkali soil. This hay, with its large percentage of ash, does not seem to be detrimental to animals, but it is an entirely open question whether the large amount of salt may not be a necessary condition for the perfect development of the plant.

The object of this bulletin is to present the facts concerning this plant so far as they are known for the consideration of our ranchmen, who need a forage plant which will produce from a fair to a good yield of reasonably good hay with but little rainfall. This plant seems to promise to fulfill all of these requirements. Though the California Station experimented with saltbushes for eighteen years and unreservedly recommended this one, the *A. semibaccata,* as the most promising one, and the Department of Agriculture at Washington distributed, if I am no mistaken, seeds of this plant, Director Wickson writes me that "the acreage in California is exceedingly small, probably not more than a small fraction of one per cent. of the amount which was contemplated." There may possibly be found an explanation for this failure of the plant to come into the popularity that its free growth and good composition seems to entitle it. They may have some other fodder which supplies their needs and is of easier culture, or easier to handle, but in those sections of our State which are of late years filling up with settlers and where the older inhabitants have had to have recourse to the Russian thistle, the coarse sand grass of the plains, or to the native saltbushes, this plant is worthy of a trial. It will not grow without any care. Even the native saltbushes are not always abundant, and this one will probably be no different except it receives intelligent planting and some nursing.

The following facts seem to have been established concerning this plant: First, when once established it will endure drought and

even make a good crop with less than five inches of rainfall.* Second, that stock will eat it or readily learn to eat it either green or as hay. Third, that it will produce very heavily under favorable conditions. Fourth, that it will, when fed alone, maintain the animals, and even better results are claimed for it. Fifth, that the hay is rich in protein, as rich or even richer than alfalfa. Sixth, that its coefficients of digestion are excellent, except for the fat or ether extract and crude fibre. Seventh, that it has no injurious effects on the animals even when they have no other fodder with it.

The following facts, however, remain, that it has not become popular, and that when fed alone it does not produce the results that its composition and coefficients of digestion would seem to warrant us in expecting. There is no reason for questioning the advisability of feeding something relatively richer in carbohydrates along with it, if they are at hand, but if they are not stock will live on this fodder alone.

RUSSIAN THISTLE.

On a preceding page reference was made to the use of this plant as a fodder. No one in any irrigated section would think of growing either the saltbush or thistle for forage. Press Bulletin 5 of this Station, by J. E. Payne, reprinted as part of Bulletin 64, reports the use of the Russian thistle in sections where other fodder cannot be raised readily. Some men report that it makes a good fodder, but other men of good judgment who have had experience in feeding this hay do not confirm the claim. Payne views it as an emergency forage. One man told me that he had tried it, feeding forty head of cattle, with very unsatisfactory results, and that many of his cattle died. As it is used to some extent in sections where there is no other available forage plant, or better where the supply of other and better plants is insufficient, I have studied the plant to a limited extent. There are only a few analyses of this fodder available. The following will serve to show the composition of the plant at various stages in its development:

ANALYSES OF THE RUSSIAN THISTLE.

	Moisture.	Ash.	Fat.	Protein.	Fibre.	N-Free Extract.
Cut June 12*.....	....	22.01	2.20	18.46	17.94	39.39
Cut June 26.....	....	18.79	1.84	17.72	23.19	38.46
Cut July 12.....	....	14.30	1.14	9.11	30.82	44.63
Small and tender†....	....	20.32	3.91	17.78	16.27	41.72
No thorns	....	21.21	3.18	14.71	22.45	38.45
Thorns out	....	18.25	2.97	13.45	21.62	43.71
Ripe	....	13.75	3.77	12.34	37.70	32.44

*California Bulletin 105.

*Iowa Bul. 26, p. 28, three samples cut June 12, 26, and July 12.

†Report Minnesota Exp. Sta. 1894, p. 35, four samples also Bul. 30.

Green thistle ‡.....	....	30.10	1.59	20.62	12.92	34.77
Hay	....	22.98	1.36	12.37	18.98	44.31
Hay	....	20.19	1.79	11.88	18.11	48.03
Green	....	29.29	1.79	19.16	12.21	37.55
Hay discolored	....	15.54	1.59	9.42	23.58	49.87
Hay, Fort Collins....	5.29	13.77	2.24	10.89	29.66	38.15

The last sample was gathered when the plants had thorns on, but were still green and succulent.

The ash constituents in this plant are high and indicate that it is a heavy feeder, especially on potash, as the analyses show. The composition of this ash seems to vary considerably.

ANALYSES OF THE ASH OF THE RUSSIAN THISTLE.

	Akron, Colorado.	Fort Collins, Colorado.	Minn.* Sample Plants Small.	Minn. Sample Thornes Well Out.	Minn. Sample Ripe.
Carbon	3.95	none			
Sand	11.25	0.90	1.93	2.43	3.95
Silicic acid	0.73	0.49			
Sulfuric acid	2.73	2.64	1.52	1.62	4.39
Carbonic acid	21.56	22.38	19.28	20.25	17.34
Phosphoric acid....	3.70	3.19	3.49	4.00	3.11
Chlorin	4.29	13.51	....	....	1.56
Potassic oxid	28.68	44.10	26.82	31.21	27.37
Sodic oxid	0.85	0.82	9.16	4.25	12.46
Calcic oxid	16.44	9.42	26.37	24.55	22.39
Magnesic oxid	5.52	5.17	9.66	7.66	5.56
Ferric oxid	0.89	0.27	0.86	1.01	0.85
Alumnic oxid.....	0.52	Trace	....	....	....
Manganic oxid (br)	0.07	0.04	....	....	....
	101.16	102.93			
Oxygen equivalent to chlorin	0.98	3.04			
	100.18	99.89	99.09	96.63	98.97

We find the phosphoric, sulfuric and carbonic acids given in the Minnesota analyses as phosphates, etc. I take it that this is a misprint and that the corresponding acid is intended.

These analyses do not agree at all. The chlorin, for instance, varies from 1.56 to 13.51, and my own samples differ by more than nine per cent. The only thing clearly evident is that this plant is a heavy potash feeder.

*Report Minnesota Experiment Station, 1894, p. 36.

‡Report Kansas State Board of Agriculture, 1902, p. 25, five samples.

Thirtieth Annual Report

OF THE

State Board of Agriculture

AND THE

State Agricultural College

INCLUDING THE

TWENTY-FIRST ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

1908

DENVER, COLORADO
THE SMITH-BROOKS PRINTING CO., STATE PRINTERS
1909

THE STATE BOARD OF AGRICULTURE.

HON. B. F. ROCKAFELLOW, Pres.	Canon City	1911
HON. JAMES L. CHATFIELD	Gypsum	1909
HON. B. U. DYE	Rocky Ford	1909
HON. EUGENE H. GRUBB	Carbondale	1911
DR. R. W. CORWIN	Pueblo	1913
HON. A. A. EDWARDS	Fort Collins	1913
HON. FRANKLIN E. BROOKS	Colorado Springs	1915
HON. J. L. BRUSH	Greeley	1915
GOVERNOR HENRY A. BUCHTEL	ex-officio.	
PRESIDENT BARTON O. AYLESWORTH	ex-officio.	

OFFICERS.

B. F. ROCKAFELLOW	President
A. M. HAWLEY	Secretary
CHAS. H. SHELDON	Treasurer

STANDING COMMITTEES.

EXECUTIVE.

B. F. Rockafellow — A. A. Edwards — B. U. Dye

FINANCE.

J. L. Chatfield — A. A. Edwards — J. L. Brush

FARM, STOCK AND VETERINARY SCIENCE.

F. E. Brooks — E. H. Grubb — J. L. Brush

FACULTY AND COURSES OF STUDY.

B. O. Aylesworth — F. E. Brooks — R. W. Corwin

BOTANY, HORTICULTURE AND ENTOMOLOGY.

J. L. Chatfield — B. U. Dye — F. E. Brooks

MATHEMATICS, ENGINEERING AND MILITARY SCIENCE.

R. W. Corwin — E. H. Grubb — J. L. Brush

MECHANICS, CHEMISTRY AND ELECTRICAL ENGINEERING.

E. H. Grubb — J. L. Brush — F. E. Brooks

COLLEGE LANDS AND LEASES.

J. L. Brush — A. A. Edwards — B. U. Dye

COLLEGE BUILDINGS AND PERMANENT IMPROVEMENTS.

B. U. Dye — E. H. Grubb — A. A. Edwards

DOMESTIC SCIENCE, LIBRARY AND MUSIC.

R. W. Corwin — J. L. Brush — A. A. Edwards

HISTORY, LITERATURE, ENGLISH AND RHETORIC.

B. O. Aylesworth — R. W. Corwin — E. H. Grubb

FARMERS' INSTITUTES.

J. L. Brush — F. E. Brooks — E. H. Grubb

FACULTY.

BARTON O. AYLESWORTH, Litt. D.
(Denver), LL. D. (Drake), President and Professor of Political Economy and Logic. Residence, 704 Matthews Street.

JAMES W. LAWRENCE, M. E.,
(C. A. C.), Dean of the Faculty and Professor of Mechanical Engineering. Residence, 206 West Myrtle Street.

LOUIS G. CARPENTER, M. S.,
(Mich. Agr. College), Director of the Experiment Station and Professor of Civil and Irrigation Engineering. Residence, 320 Plum Street.

CLARENCE P. GILLETTE, M. S.,
(Mich. Agr. College), Professor of Zoology and Entomology. Residence, 620 Elizabeth Street.

WILLIAM P. HEADDEN, A. M., Ph. D.,
(Giesson), Professor of Chemistry and Geology. Residence, 120 West Magnolia Street.

EDWARD B. HOUSE, B. S.,
E. E. (Univ. of Mich.), M. S. (C. A. C.), Associate Professor of Irrigation Engineering. Residence, Elizabeth Street.

ALFRED M. HAWLEY,
Secretary of the Faculty. Residence, 212 South College Avenue.

VIRGINIA H. CORBETT, B. L.,
(Iowa State College), Professor of History and Literature. Residence, 428 West Laurel Street.

WENDELL PADDOCK, M. S.,
(Mich. Agr. College), Professor of Botany and Horticulture. Residence, Elizabeth Street.

GEORGE H. GLOVER, M. S., D. V. M.,
(Iowa State College), Professor of Veterinary Science. Residence, 608 South Howe Street.

WILLIAM RUSSELL THOMAS, A. B.,
(Williams), Litt. D. (Denver Univ.), Professor of Constitutional History and Irrigation Law. Residence, 123 West Magnolia Street.

*

Head of Department of Agriculture, Professor of Agriculture.

CHARLES A. LORY, M. S.,
(Univ. of Colorado), Professor of Physics and Electrical Engineering. Residence, 901 Stover Street.

B. F. COEN, B. L.,
(Univ. of Wisconsin), Professor of English. Residence, 334 East Mulberry Street.

ROBERT W. GAY, C. E.,
(New York Univ.), Associate Professor of Civil Engineering. Residence, 229 West Mulberry Street.

H. M. BAINER, M. S.,
(Iowa State College), Professor of Farm Mechanics. Residence, 900 Smith Street.

LESLIE F. PAULL, A. M.,
(Brown), Associate Professor of Horticulture. Residence, 704 Remington Street.

S. L. MACDONALD, B. S.,
(Ind. State Normal), Professor of Mathematics. Residence, 424 West Olive Street.

HARRY D. HUMPHREY, Capt. U. S. A. (Ret.),
Professor of Military Science and Tactics. Residence, 231 South Howe Street.

GEORGE E. MORTON, B. S. A.,
(C. A. C.), Professor of Animal Husbandry. Residence, 220 Elizabeth Street.

FRED C. ALFORD, M. S.,
(C. A. C.), Associate Professor of Chemistry. Residence, 124 West Magnolia Street.

S. ARTHUR JOHNSON, M. S.,
(Rutgers), Associate Professor of Entomology. Residence, 600 Block Elizabeth.

BURTON O. LONGYEAR, B. S.,
(Mich. Agr. College), Associate Professor of Botany and Forestry. Residence, 719 Remington Street.

*To be filled.

MARY F. RAUSCH, B. S.,
C. A. C.), Professor of Domestic Science. Residence, 720 Peterson Street.

H. M. COTTRELL, M. S. A.,
(Kansas Agr. College), Superintendent of Farmers' Institutes and Extension Work. Residence, 821 Peterson Street.

ISAAC E. NEWSOM, B. S.,
(C. A. C.), D. V. S. (San Francisco Vet. College), Associate Professor of Veterinary Science. Residence, 412 West Magnolia Street.

JOSEPH F. DANIELS,
Librarian and Professor of Library Science. Residence, 631 Whedbee Street.

H. E. KINGMAN, D. V. S.,
(Kansas City Vet. College), M. D. V. (McKillip's Vet. College, Chicago), Associate Professor of Veterinary Science. Residence, 606 South Howe Street.

SARAH I. KETTLE, A. B.,
(Univ. of Colorado), Professor of Modern Languages.

*.....,
Professor of Agronomy.

---

*To be filled.

INSTRUCTORS AND ASSISTANTS.

CHARLOTTE A. BAKER,
Assistant in Library. Residence, 620 South Howe Street.

E. R. BENNETT, B. S.,
(Mich. Agr. College), Assistant in Horticulture. Residence, 426 Remington Street.

H. B. BONEBRIGHT, B. S. A.,
(Iowa State College), Assistant in Farm Mechanics. Residence, Y. M. C. A. Building.

REBECCA R. BOSWELL,
(Drexel), Instructor in Domestic Art. Residence, 426 Remington Street.

L. C. BRAGG,
Curator of the Museum. Residence, 818 Remington Street.

MARY J. BRUSH,
(Framingham), Instructor in Domestic Science. Residence, 500 South College Avenue.

BUSMAN, H., M. D., D. V. S.,
U. S. Meat Inspector. Denver, Colo.

ALBERT CAMMACK, B. M. E.,
(Iowa State College), Assistant in Mechanical Engineering. Residence, 510 South Howe Street.

CHARLES N. COX, S. B.,
(Colorado College), Assistant in Chemistry. Residence, 324 South College Avenue.

LOTTA I. CRAWFORD, B. S.,
(Kansas Agr. College), (Pratt), Instructor in Domestic Science. Residence, 504 Plum Street.

FRED W. CULVER, M. D. C.,
(Chicago Vet. College), Dentistry.

EARL DOUGLASS, M. S.,
(C. A. C.), Assistant in Chemistry. Residence, 220 West Mulberry Street.

ALEXANDER EMSLIE,
(Boston Conservatory of Music), Director of the Conservatory of Music, Instructor in Voice Culture, Oratorio and Opera; Chorus Director. Residence, 642 Peterson Street.

MRS. ALEXANDER EMSLIE,
(Indianola Conservatory of Music), Instructor in Piano and Accompanist. Residence, 642 Peterson Street.

MARGUERITE R. FRINK, B. A.,
(Denver Univ.), Assistant in Mathematics. Residence, 202 W. Mulberry.

EDNA GARBUTT, B. S.,
(C. A. C.), Assistant in English. Residence, 307 Riverside Avenue.

MARIE T. GILL, M. A.,
(Univ. of Colorado), Assistant in Mathematics. Residence, 528 S. College Avenue.

CHARLES GOLDING-DWYRE, JR., B. Acct.,
(National Business Inst.), Instructor in Bookkeeping. Residence, 649 Remington Street.

EDNA GROVE,
(Amity School of Oratory), Instructor in Elocution. Residence, 209 W. Mulberry.

E. J. IDDINGS, B. S.,
(C. A. C.), Assistant to Professor of Agriculture. Residence, 720 Matthews Street.

NELLIE M. KILLGORE (Pratt), B. S.,
(C. A. C.), Instructor in Drawing. Residence, 225 Remington Street.

FRITZ KNORR, B. S.,
(C. A. C.), Associate Professor of Agronomy. Residence, 1117 Matthews Street.

CHARLES G. LAMB, D. V. S.,
(Montreal Vet. College), State Veterinarian, Special Lecturer in Veterinary Science. Residence, Denver, Colorado.

FRED N. LANGRIDGE, M. E.,
(C. A. C.), Assistant in Mechanical Engineering. Residence, 510 S. Howes Street.

F. C. McLAUGHLIN,
College Secretary Y. M. C. A. Residence, 327 Remington Street.

NELLE E. MARLATT,
(Indianola School of Music), Assistant in Voice Culture, Public School Music and Sight Reading. Residence, 209 W. Mulberry Street.

ANNE PARKER MINER,
(New England Conservatory of Music), Instructor in Piano and Theory. Residence, 402 Remington Street.

L. M. MONTGOMERY, B. S.,
(C. A. C.), Assistant in Horticulture and Landscape Gardening.

WILLIAM O'BRIEN,
Farm Superintendent. Residence, College Farm.

MRS. LENA DAVIS PAULL,
Instructor in Modern Languages. Residence, 704 Remington Street.

JAMES PENNYCOOK,
Instructor in Horseshoeing. Residence, 327 Garfield Street.

MIRIAM A. PALMER, A. M.,
(Univ. of Kansas), Artist for Experiment Station. Residence, 818 Remington Street.

RALPH PARSHALL, B. S.,
(C. A. C.), Assistant in Civil and Irrigation Engineering. Residence, 926 Akin Avenue.

HIRAM PIERCE,
Instructor in Carpentry. Residence, 510 S. Howes Street.

A. W. ROTH, M. D.,
Lecturer Ophthalmology. Residence, South College Avenue.

CLAUDE J. ROTHGEB,
Physical Director. Residence, 612 South College Avenue.

L. M. TAYLOR,
Secretary to the President. Residence, 500 South College Avenue.

ROBERT E. TRIMBLE, B. S.,
(C. A. C.), Assistant in Meteorology and Irrigation Engineering. Residence, 210 West Laurel Street.

W. O. UPSON, M. D.,
(Northwestern), Lecturer in Veterinary Department. Residence, Knemeyer Building.

D. J. H. WARD, A. M.,
(Harvard), Ph. D. (Leipsic), Assistant in Physics. Residence, 315 Remington Street.

C. M. WOOD,
Leader of the Cadet Band. Residence, Court House.

HELEN M. GRENFELL,
Field Lecturer. Residence, Denver, Colorado.

J. F. TUTTLE, JR., LL. B., A. M.,
(Harvard), College Lecturer. Residence, Denver, Colorado.

LETTER OF TRANSMITTAL.

To His Excellency,

THE GOVERNOR:

Sir—Herewith I transmit my annual report as Secretary of the State Board of Agriculture. It is respectfully commended to your attention and to the thoughtful consideration of the General Assembly.

A. M. HAWLEY,
Secretary of the State Board of Agriculture.

The State Agricultural College,
Fort Collins, Colorado, November 30, 1908.

REPORT OF THE PRESIDENT.

The State Board of Agriculture:

Gentlemen—I submit herewith reports from the heads of the various departments of the Colorado Agricultural College, for the year ending November 30th, to which I invite your careful attention.

My own report at this time will be very brief, since it is my purpose to present at the end of my term of office a report covering the ten years of our co-operation.

It gives me unusual pleasure to state that there is perfect harmony in the College. Never has there been such evidence of solidarity. Never has there been a time when every member of the College, from the lowest to the highest, has been in more perfect accord with not only the members of his own department, but with those of all other departments. I am convinced, too, that the quality of work has never been surpassed. It would seem that every man not only feels the importance of his position, but is giving to it the full measure of his powers.

The student body, being almost without exception high-school graduates, is showing a college spirit and application to work of the finest sort.

There is a compactness, an *esprit de corps,* a marching together, which is most commendable. There are as many seniors as last year; twenty-five more juniors, eleven more sophomores, and three more of freshman rank, there being 112 in this year's freshman class.

The short course which began its work in November last has an enrollment of 106. There will be others entering after the Christmas holidays.

The student organizations are well officered, loyal to the administration, and performing remarkably well their several functions.

The faculty, united, is in that most desirable attitude of awaiting your instructions, determined that the policy of the board shall be its policy.

The support of the local press and of local organizations is given the College without reserve. I am confident that there has never been a time in the history of this institution when everything has so conspired to a great forward movement as will surely come under the efficient leadership which your wisdom will provide. If I may be permitted, I desire to submit a few suggestions.

I think I need not counsel you not to depart one iota from the letter and the spirit of the law which established and maintains these land-grant colleges as "high seminaries of learning,

where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts."

As in other States, that battle has been fought in Colorado and won on the side of the law and sane, approved, scientific education.

I desire further to call your attention to the high schools of the State. While we have cultivated their friendship and sent to them yearly a representative of the College with good results, the time has come when some one should devote all or the greater part of his time to cementing these preparatory schools and the Agricultural College. Not alone by a thorough visitation and an exploitation by models, samples and stereopticon lectures the work of this College, but by helping to so reshape their courses of study as to give better opportunity, certainly greater incentive to select such a high school course as will lead to this institution. Here lies one of, if not the most important work of this board and your faculty during the next five years.

I wish to again call attention to the demand for a four-years' industrial preparatory school to be established here under your supervision for the benefit of those graduating from the eighth grade who may not have high school privileges at home, and for those who may prefer more practical preparatory work than is usually provided in high schools.

One-third or more of our correspondence is in relation to such a school. The present faculty is willing to add to its duties the labor of helping to establish here such an industrial preparatory school, knowing the demand for it and fully realizing the great service it would render the College itself.

By an alternation of recitations and laboratory work with that of the College, as now scheduled, the present buildings would be ample. A head master and three or four additional assistants would be sufficient help for the first two or three years.

The faculty has with great care prepared a course of study for your consideration which they believe would meet the demands of such a school. I herewith submit a copy.

This preparatory school would double the enrollment of students at once. A small fee of from $10.00 to $20.00 a year could be charged under the laws governing the College which would almost cover the additional expense. It is worthy your consideration in the program of your growing College. It would complete the triangle of Agricultural College education. A preparatory school for the graduates of the common schools, which would either lead to the College courses or be more or less complete in itself for those who desire both practical and cultural education of a limited nature; next, the winter short courses already so successfully established for those who, older, lack either

time or means, or both, for a more thorough training; and then the long courses as now established, leading to the degree of B. S. for those who desire technical and special preparation in agricultural, veterinary, horticultural or engineering lines. All these statements relate as truly to domestic science for young women.

I believe some co-operative work should be undertaken with the State Normal School looking to the preparation of teachers of elementary agriculture in the rural schools. A beginning might be had by offering a summer school course at the Agricultural College, using our buildings, equipment and teachers, under the joint supervision of the College and the State Normal School. Before agriculture may be introduced into the common schools there must be a preparation for instruction in agricultural branches.

You should appoint at this meeting a legislative committee, whose special concern shall be the securing of much larger appropriations for the College from the Legislature. Either the permanent income must be increased to two-fifths of a mill, or greatly increased special appropriations obtained.

The College has outgrown its revenues. The increase of its extension work, which in no wise meets the present and constantly growing demands—a work so helpful to both the State and the College; the need for more buildings and new equipment, the increasing rate of living—making it necessary to increase the salaries of some of your employes—the greater demand for experimental work along many lines, all make it imperative that the claims of the Agricultural College shall be presented to the incoming Legislature as they have never yet been presented. The people are ready to help, organizations are proffering their assistance; you can double your revenues if you become urgent.

The animal husbandry department is at present in charge of Professor Morton; the department of agronomy is in charge of Professor Knorr; that of farm mechanics and dairying is under Professor Bainer; the farm and stock not otherwise supervised as above indicated are in charge of Mr. O'Brien, and the government horse-breeding plant under Professor Williams, sent out by the Department of Agriculture, at Washington, all reporting directly to the President of the College.

I have a few minor recommendations to offer later in this session relative to the immediate needs of the College.

B. O. AYLESWORTH.

ERRATA

(*To insert between pages 14 and 15*)

Through error in make up, portions of the Report of the Experiment Station have been misplaced and various other errors occur.

From pages 15 to 30 inclusive, is part of the report of the Experiment Station and should follow page 148.

the cost was to be small, for during several years the sum available could not much exceed $100. This led to some projects, not such as would have been taken from choice, but from the necessity of the situation. Fortunately, some of these, whose merit was cheapness, proved to be of much value. Some of the questions relating to water-supply, to seepage matters, to measurement, were taken up. These became important because of the serious questions involving the fundamental water ownership and rights of the whole State. It was based on some of the investigations of the station that the successful defense of the State of Colorado against the attack of the State of Kansas was successfully made, and the result has been immediately seen in the activity in irrigation development since the determination of this question by the Supreme Court.

There has been a large amount of data in various lines, the results of measurements, of continued observations and of records, and it is now of pressing need that these be reduced and prepared for publication. This needs to be done to prepare for taking up other work in contemplation. The restricted quarters, the lack of laboratory space, has prevented the consideration of much work of importance and the laboratory tests in connection with plants and the use of water. With the new building, which it is hoped will be available during the coming year, this restriction will be removed and the limitations largely removed.

The danger to the valuable records has been a source of constant anxiety for some years back, but, fortunately, we have not suffered. There is, however, the constant risk. The same conditions have restricted the room and the opportunity for doing work requiring room.

The work of the past year has been along the lines of the plans adopted, and is the continuation of plans in force for some time. Special progress has been made in the reduction of some classes of the observations that now have become of great value. These it is hoped to systematically reduce. Without more room it is hardly possible to consider more aid for that purpose.

Respectfully submitted,

L. G. CARPENTER.

ANIMAL HUSBANDRY.

To the Director:

Dear Sir—The experimental work in live stock, as planned for the summer of 1908, has been carried out. The ration experiment with swine upon pasture was carried on for nine weeks, and has now been closed. Five lots of pigs, fourteen in each lot, were fed as follows:

Lot 1—Rape pasture; 1 per cent. of live weight in corn.

Lot 2—Rape pasture; 2 per cent. of live weight in corn.

Lot 3—Dry lot; corn at pleasure.

Lot 4—Alfalfa pasture; 2 per cent. live weight in corn.

Lot 5—Alfalfa pasture; 1 per cent. of live weight in corn.

Respectfully submitted,

C. E. MORTON,
Animal Husbandman, Agricultural Section.

Fort Collins, Colorado, November 1, 1908.

AGRONOMY SECTION.

To the Director:

Dear Sir—I hereby respectfully submit to you the following report:

No. 1. To develop a hardy type for higher altitudes.

No. 2. To develop a drouth resistant type for non-irrigated lands of the West.

The preliminary work for these experiments has been conducted in the alfalfa breeding nursery for three years. As soon as desirable stocks (hardy and drouth resistant) have been established in the nursery they will be taken to those localities for which they are specially adapted. Next spring we hope to send alfalfa stock to Gunnison.

No. 3. To develop a forage type for the irrigated lands which shall yield a desirable quality and increase the quantity of forage now produced by our present type of alfalfa.

In our plant-breeding nursery we now have alfalfa stocks from nearly all sections of the globe. Here we are testing the individuality of each plant, constantly adding new stocks that seem desirable and eliminating the undesirable ones.

Considerable close-hand pollenation has been done; by this means some excellent stocks have been developed. We now have more than 6,000 individual plants in the nursery; about two hundred of these are the specially selected hand pollenated stocks.

CORN.

No. 1. To breed up an acclimated type of dent corn which shall possess more desirable physical characteristics and be hardy for altitudes from 4,000 to 6,000 feet.

This work has now been in progress for five years. Although this work is making good progress, it is a question in my mind if this would be of any advantage to the farmers of the irrigated sections. If this work could be continued on dry land, it would be of greater value to the farmers of Colorado.

BARLEY INVESTIGATION.

No. 1. To obtain a desirable drouth-resistant barley, without beards, for lands above the ditch.

For this work all possible beardless varieties that could be secured were planted in the spring of 1908. Several beardless varieties in the nursery were crossed with our best bearded varieties, in order to seure desirable types of beardless barleys.

No. 2. To obtain a good quality, high-yielding feed barley, without beards, for irrigated lands below 6,000 feet.

This work is along the same line as the above.

No. 3. A very early type for the higher altitudes.

A number of very early maturing stocks from the College were placed in several localities at an altitude of from 8,000 to 10,000 feet. This year these stocks proved fairly satisfactory.

No. 4. A more desirable malting type for irrigated lands.

Nothing has been done with this, and it may be advisable to drop this work.

MEADOW AND PASTURE GRASS INVESTIGATION.

Nothing has been done with this, except that a number of stocks have been planted in the plant-breeding nursery.

OAT INVESTIGATION.

No. 1. Development of a superior milling oat for the higher altitudes of the inter-mountain region of the West.

This was carried on in the regular plant-breeding work in centgener plots. This work will be continued in the nursery for several years.

No. 2. Do the various types of oat differ in drouth-resistant power, and can this be intensified in breeding by selection?

Nothing was done with the above.

STOCK ROOT INVESTIGATION.

To determine the best type of roots, under Colorado conditions, for economical feeding of beef, pork and mutton.

For the past two years a number of varieties of stock roots were planted, with the object of selecting varieties best adapted for Colorado conditions. In the fall of 1908 it was considered a good plan to cross some of our mangles with the sugar beet, in order to secure a better keeper than the common mangles.

Several very good stock carrots were saved from the 1907 crop (these were planted in my home garden, and seed was grown from these); that year over 75 per cent. of the carrots died from rot. It is hoped that this seed will prove rot resistant.

SUGAR BEET EXPERIMENT.

No. 1. To determine the effects of various fertilizers and manure upon purity and sugar contents of the beets; the residual effects of commercial fertilizer and manure upon the soil; crop rotation by continuous culture.

This was carried out as planned, and is now in its third year.

No. 2. Cultural methods, including tillage, seeding, harvesting and siloing.

This was carried out as planned. The results of this work are most gratifying.

No. 3. Determine the minimum amount of water that will grow a maximum crop of beets.

This was carried on as planned, with the exception that the water used was not measured; the plats were simply irrigated one, two, three, four and five times.

SPRING MILLING WHEAT.

To determine the cause of deterioration in spring milling wheats on the irrigated lands and in the higher altitudes. In connection with this project wheat was grown by the Experiment Station and three co-operators in three different sections of the State. One of the co-operators at Carbondale, altitude 6,100 feet; Alamosa, 7,546 feet, and Rocky Ford, 4,180 feet. This is the first year of the work. As soon as the milling apparatus and necessary equipment can be installed, the milling tests will be carried out, as outlined in the plan.

Respectfully submitted,

F. KNORR,
Acting Agronomist.

Fort Collins, Colorado, November 1, 1908.

FARM MACHINERY.

To the Director:

Dear Sir—I hereby respectfully submit the following brief report of experimental work in farm mechanics:

Last April these outlines of work were submitted to be carried out between then and June 30, 1909. The subjects of these outlines were as follows:

Cement posts for farm use.

Feed grinders, cutters and crushers.

Farm buildings and construction.

The first subject—"Cement Posts for Farm Use"—is just completed, as far as the experimental work is concerned. The data have been secured and are ready to be written and arranged in bulletin form. We desire to get this material in shape for publication by November 30, 1908. Neither of the other two subjects has been started.

We hope to carry out the second line of work—"Feed Grinders, Cutters and Crushers"—between now and June 30, 1909.

It seems necessary to omit the last line of work for the present time on account of the limited amount of help in the department and the large amount of instructional work to be given.

About $1,200 out of the $2,000 appropriated by the State for experimental work has been used during the past summer for erecting additional machinery space for the department machinery. This space is in the form of an addition to the old farm mechanics' building and covers a space 36x66 feet. It has ten-foot posts with floor above for light machinery.

Mr. H. B. Bonebright, assistant in farm mechanics, has spent about one-half of his time since last January working with the cement fence post experiment. I have also spent a great deal of my time during the past six months in the same line of work.

Respectfully submitted,

H. M. BAINER,
Professor of Farm Mechanics.

Fort Collins, Colo., November 1, 1908.

REPORT OF HORSE BREEDING INVESTIGATION.

To the Director:

I beg to submit to you a brief report of the horse breeding investigation as conducted in co-operation with the U. S. Department of Agriculture for the period beginning with my appointment as expert-in-charge, October 22, 1908, up to the present time.

STUD RECORD SUMMARY.

There are at present in the stud seventy-six (76) animals, consisting of the following:

1 stallion.
28 mares in service.
8 two-year-old fillies.
2 two-year-old colts.
4 two-year-old geldings.
7 yearling colts.
9 yearling fillies.
9 male foals.
8 filly foals.

76 total number in stud.

There have been no additions made to the stud during the time aforementioned, but the above summary includes the mares and foals purchased during the summer and their addition to the stud is of such importance as to deserve special mention at this time. The purchase was made by the original purchasing board composed of Mr. Geo. M. Rommel, Animal Husbandman of the Bureau of Animal Industry; Prof. W. L. Carlyle, Expert in Animal Husbandry, and Director C. F. Curtiss, of the Iowa Experiment Station. The mares purchased represent blood lines that are producing the best carriage horses in Kentucky. Three were sired by Wilson's King, and the fourth by Chester Dare, the grandsire of Ahma, second prize carriage brood mare at the 1907 Blue Grass Fair. This is the best blood that can be obtained in Kentucky at the present time and its introduction into the experiment should prove very valuable in the results attained.

The mares were all in foal when purchased, and all have foaled since purchasing. The mares, Barthania, McCord and Elvira Lindsey were bred back to Bourbon King, and the mares Golden Picture and Bethel Princess were bred to Golden King before being shipped to Colorado. Some of these mares will be eventually mated with Carmon, and the refinement and quality

which is characteristic of these blood lines should be of great value in the production of carriage horses of the proper type.

ELIMINATION OF UNDESIRABLE ANIMALS.

A number of animals in the stud at the present time have been recommended for disposal. There are fifteen animals in all to be culled and include the following:

Mares:

Brown mare—California.

Bay mare—Florida.

Chestnut mare—Minnesota.

Three-year-old fillies:

Brown filly—Idalia.

Bay filly—Monella.

Two-year-old filly:

Bay filly, out of Idaho.

Two-year-old geldings:

Brown gelding, out of California.

Brown gelding, out of Illinois.

Yearling fillies:

Chestnut filly, out of Minnesota.

Bay filly, out of Michigan Lady.

Yearling colts and geldings:

Bay gelding, out of Illinois.

Bay colt, out of Wisconsin Queen.

Foals:

Chestnut filly, out of Minnesota.

Bay colt, out of Florida.

Bay colt, out of Monella.

Of the above recommendations, one has already been disposed of; the yearling colt, out of Wisconsin Queen, having been destroyed in accordance with a board resolution passed during the last meeting.

The above recommendations were submitted to Dr. A. D. Melvin, chief of the bureau of animal industry, by the former board of survey composed of the members of the purchasing committee aforementioned.

The recommendations have been favorably acted upon by the department and the animals the property of the department ordered to be sold by the present board of survey composed of the writer as chairman, Prof. C. F. Curtiss and Mr. Geo. M. Rommel.

The animals the property of the department which were condemned and recommended to be sold are the mares California,

Florida and Minnesota, and the three-year-old fillies, Monella and Idalia.

The remaining condemned animals are the property of the experiment station and are subject to sale at its discretion. I trust some suggestion will be submitted as to the best manner of disposing of these animals. As it is quite essential that the identity of these animals with the experiment be lost, because of their inferior qualities, the manner of disposing of them deserves some deliberation. It has occurred to me that it would probably be advisable to place them in some good market, such as Omaha or Kansas City, and allow them to bring whatever the open market afforded. This would insure a total loss of identity, but on the other hand a slight sacrifice of proceeds of sale might occur. The matter, however, is left to your discretion, and I trust some recommendation will be made for their sale, as the horses should be disposed of at once.

IMPROVEMENT.

The improvements made have been only those of urgent character. Two sheds have been built approximating an expenditure of about $200.00. Water lines have been installed in three paddocks, the remaining paddocks having been previously equipped with water.

MAINTENANCE OF ANIMALS.

The majority of the brood mares are kept on pasture in the foothills with a daily allowance of upland hay. The mares with foals, stallions, young stock, and mares which do not thrive on pasture are kept at the barns for constant attention.

The young stock is maintained on a ration of oats, alfalfa and upland hay. They are very thrifty and are growing nicely.

CONCLUSION.

The development of the young stock indicates that progress is being made in attaining the proper type of carriage horse. With the condemned horses eliminated, and a continued process of judicious breeding practiced, the outcome of the experiment can be none other than successful.

Respectfully submitted,

J. O. WILLIAMS,
Expert in Charge.

Fort Collins, Colo., Dec. 8, 1908.

REPORT OF THE VETERINARIAN.

To the Director:

There are at the present time no animal diseases threatening the security of the live stock interests of the State. There are, however, a few diseases that are a constant menace to this industry, and while at the present time none of them has assumed the proportion of an epizootic, yet in the aggregate they claim an annual mortality that makes the raising of live stock as a business more or less hazardous.

These diseases are at all times to be reckoned with, not only because of a certain small loss, but because of the danger of their assuming wide-spread proportions and not only claiming the profits of the business, but a goodly proportion of the principal invested as well. The specific cause, prevention, and treatment are as yet little understood and are problems which can only be mastered by diligent scientific co-operation of field work and laboratory.

The most important diseases within the State, named casually in the order of their probable economic significance, are as follows: Tuberculosis, mostly in cattle and swine; necrotic stomatitis in hogs and calves, poisonous plants on the open range, black-leg and anthrax, strangles in young horses, hog cholera, mange of cattle in the western half of the State, scabies in sheep, contagious abortion, parasitic diseases, calf scours, swamp fever in horses, and glanders.

LOCO WEED INVESTIGATION.

This is the fourth season of our co-operative investigation of the loco weed problem in conjunction with the department of agriculture. This undertaking has been co-operative only to the extent that we have furnished the live stock. One thing seems to have been determined beyond what the western "cow man" already knew, and that is the specific nature of the poison, which, according to the report of the biochemic division of the bureau of animal industry, is barium. As an addition to science this discovery alone has unquestionably justified the investigation. The practical solution of the loco problem, however, does not rest with the discovery of the causative agent, but must be prophylactic or curative to have any economic value.

As no information has been furnished us regarding this season's work, I am unable to report anything definite. The efforts of the U. S. Department of Agriculture to bring to light

the long hidden mysteries of this perplexing problem in the interests of science and a great western industry are certainly worthy of commendation and warrant the generous appreciation and co-operation of the western stockman.

NECROTIC STOMATITIS.

During the winter months a year ago this disease reached the proportions of a veritable scourge among the swine in almost every section of the State.

The disease assumed a degree of virulency never before reported. Thousands of young pigs died and older ones in many cases succumbed. The specific organism (bacillus necrophorus), which, no doubt, is responsible for this condition, is also an invader in hog cholera outbreaks, and the post mortem as well as ante-morten lesions, in necrotic stomatitis, range all the way from those characteristic of this disease to those typical of hog cholera.

Necrotic stomatitis is commonly spoken of as sore mouth disease in pigs and calves. This name, however, is a misnomer, as the mouths are often not in the least affected.

In some cases we find ulceration of the walls of the stomach, with deep-seated necrotic areas, and tumefaction of the muscular coats. In most every case, deep sloughing sores may be found on the feet, tips of the ears, nose, or in some unusual place on the surface of the body.

Control of the disease seems not to be difficult when active measures properly directed are adopted. A thorough, systematic quarantine and disinfection have been recommended by letter, through the press, and by personally visiting the diseased herds.

The things especially recommended have been the removal of healthy animals to new quarters, the burning of all litter, disinfecting feed troughs, and dipping all the hogs once, and the little pigs every three days, in a solution of potassium permanganate, one ounce to one gallon of water.

HOG CHOLERA.

The conditions for raising hogs in Colorado approach the ideal. This fact is becoming appreciated, and, as a result, hog-raising has taken an impetus in the last two years, which augurs well for the future of this industry in Colorado. Hog cholera has not as yet caused much loss, and there are those who make the sweeping claim that hog cholera and other contagious diseases need not be feared because of the favorable climatic conditions in the arid West.

These claims, in the main, are not substantiated and the danger is that we become overzealous in this respect and relax our vigilance in necessary quarantine and sanitary measures. We have already lost enough hogs from cholera in the West

to effectually refute such ill-advised statements. The fearful loss from hog cholera in this country actuated the U. S. Department of Agriculture to undertake a thorough investigation, with the hope of securing a remedy or, better still, a means of protecting hogs against this disease.

After several years of diligent research, an effective means of immunizing hogs against cholera has undoubtedly been secured. That this product, known as Dorset's hog cholera serum, will protect hogs against the disease cannot be doubted. The objections to it are two-fold, viz., the expense in its manufacture, and the danger of distributing the virus among careless veterinarians and uninformed farmers.

The Kansas experiment station has undertaken to produce a protective serum by passing the cholera virus through the horse. The claim is made that this method will successfully protect the hog against hog cholera, and at the same time avoid the objectionable features of the Dorset method.

While it is practically certain that we now have a sure method of preventing the spread of hog cholera, the fact remains that farmers are themselves largely responsible for the spread of the disease, and the education of the farmer as to the nature of the micro-organism which causes disease is, after all, the principal safeguard.

In accordance with your instructions, arrangements are now being made to start in the work of making the Dorset hog cholera serum. It is doubtful if the serum can be made and administered in remote sections of the State for less than forty cents a dose. We shall undertake the work in a limited way and enlarge upon the work if circumstances warrant us in so doing.

Respectfully submitted,

GEO. H. GLOVER,
Veterinarian.

Rocky Ford, Colorado, October 23, 1908.

L. G. Carpenter, Director:

The efforts of the field agent at Rocky Ford, during the past season, have been largely confined to the alfalfa seed breeding investigations, attempting to develop a better type of hay and seed yielding alfalfa; also endeavoring to determine the conditions and cultural methods necessary for the highest yields of alfalfa hay, and a more uniform production of the seed crop.

The results of these efforts may be briefly summarized, in the following observations and results, from the plats of different varieties and individual selections, all under the same conditions. Marked contrasts of practical value were revealed, in hardiness, in early spring development, frost resistance in spring, and in the tendency to lodge, with wind and rain. The character of the stems, and profusion of the leaves desirable for hay, and the tendency to good yields of seed, were variations of still more interest and value. Some of the plats would easily have produced double the yield of hay; of others, and of the sixty-four plats, comparatively few produced any seed, yet several were almost phenomenal in this respect; as high as four and one-half pounds from one hundred and seventy-five plants, that grew on one plat of two square rods; some individual plants produced as high as two ounces of seed. The plats of relative high merit were selected, and all the seed that was possible from them saved to continue the work in this line. About thirty-five pounds of seed was secured, ranging in amounts from one-half to four and one-half pounds from a plat.

Considerable effort was devoted to the study and determination of the principles that underlie the setting of alfalfa seed. The indications point to two factors: Weather conditions, and hereditary tendency. The latter may be controlled by seed selection, it is evident almost beyond doubt.

The experiments with the cantaloupe for disease resistance have been more of secondary consideration, as the results of our investigation in this line have been so manifestly successful that it is now clearly the work of the practical seed breeder rather than the experimenter.

It is gratifying to report that the practical merits of the "Rust-resistant" strain of cantaloupes developed by the Station is receiving recognition from growers; not only in the vicinity of Rocky Ford, but from the whole United States inquiries and reports are coming in. This strain is being extensively planted, and except for the one objection, its late maturity, it would soon become the exclusive strain. But as the earlier maturing cantaloupes capture the highest prices, and net the grower the

greatest returns, the early strains will still be grown to a large extent, even though they are expected to go down with disease. It is an unfortunate condition, for the diseased melons demoralize the markets with poor and uncertain quality, thus injuring the returns for the later cantaloupes of even first quality.

Disease resistance and early maturity, is a combination much needed. To get this result, the rust-resistant strain has been hybridized with the earliest strain, using the cross both ways. The final results of such an effort may require several years to accomplish, yet the indications promise decided results, as one of the selections from a hybrid of the second generation matured early, and was strongly resistant to the melon blight. The seed of this selection will be submitted to a field test this coming summer. One of the plants that was used in the crosses this season matured ripe cantaloupes in thirty-five days after the flowers were pollenated, which is nearly a week earlier than the average early strains. Several other hybrids were made this season, with a variety from Smyrna, and one or two other varieties that we have secured from the United States Department. The specific objects of these crosses were to improve the quality of cantaloupes, and to trace the laws of heredity in the melon. These hybrids, and a comparative test of some material secured in previous work in this line, constitute the extent of the cantaloupe investigations the past year.

The sugar beet investigation has been rather inert, for several reasons. The spirited controversy between the factory management and the farmers, and the unfavorable season, due to the shortage of rains and irrigation water, has discouraged any effective co-operative work. Outside of some general field observations, little has been attempted in this line. The sugar beet industry in the Arkansas valley has been severely injured this season by unfavorable climatic conditions, and the prevalence of the "curly top" trouble, root aphis, and several of the fungus diseases of the beet. Our investigation in developing a beet resistant to the curly top resulted last year in a failure of the seed to germinate, thus terminating at present the efforts in this line.

On several occasions during the summer assistance was rendered the Farmers' Institute corps under Prof. H. M. Cottrell. Addresses were made at Rocky Ford, Hotchkiss, Bristol, Hartman, Granada, Amity, Holly, Cortez and Mancos. An address on breeding cantaloupes was prepared and read before the American Breeders' Association, at Washington, D. C., January 26, 1908. Also, another article was prepared for the Denver Chamber of Commerce, on the subject of the cantaloupe industry.

The above is submitted as the general report of the field agent at Rocky Ford.

Respectfully submitted,

PHILO K. BLINN.

Cheyenne Wells, Colorado.

To the Director:

I desire to submit the following report on the above farm, situated in Cheyenne county, Colorado:

The year just passed has been an exceptionally dry one, less than ten (10) inches of rain having fallen during the entire year, and this season about three and one-half (3½) inches up till the first of August. During the month of August about two and one-half (2½) inches, and on the 18th of October about five (5) inches, making a total for the year of about eleven (11) inches.

The spring being so unusually dry, planting and seeding was all done quite late. The 6th of May there was seven (7) acres of ground sown to macaroni wheat; on the 8th of May there was five (5) acres sown to side oats, which did but little good, and on the 19th and 20th of June was ruined by hot winds. Weeds were in evidence on this ground, notably the Russian thistle, and this, with what little wheat and oats remained, were cut for cattle feed, making about a ton of feed to the acre.

On the 13th day of May there was eight (8) acres planted to corn, but, owing to the dry weather, did but little good, and on two different times was materially damaged and ruined by hail; was planted over to cane on the 20th of June, and was left stand to pasture in the field. On the 3d of June there was ten (10) acres planted to cane, which yielded about a ton of feed to the acre. On the 10th of June there were eight (8) acres sown to hersey grass, which germinated very slowly, and which came up very uneven and made a very small crop, and was well mixed with Russian thistles.

Garden of a general character, as well as potatoes, were put out, but proved an absolute failure.

THE ORCHARD DIVISION.

Trees have done no good at all; no fruit on account of the late freezing in the spring, and the trees have made no noticeable growth. The two dry years of the past have drawn all the moisture from the ground, and has so remained until the big rain of the 19th of October.

Many trees show the effect of dead limbs in parts of the tree. The orchard proper was deeply cultivated the early part of October, in anticipation of some moisture, so that the rain that did come was thoroughly saved, and therefore the orchard goes into the winter in as fair condition as can be expected after the prolonged drought.

There have been sown fifteen (15) acres of fall wheat (turkey red). This wheat was sown during the past month. Also, five (5) acres of rye have been put in.

Dated this 9th day of November, A. D. 1908, at Cheyenne Wells, Cheyenne county, Colorado, and respectfully submitted.

Yours truly,

J. B. ROBERTSON.

REPORT OF DIVISION OF AGRONOMY.

To the State Board of Agriculture:

Gentlemen—I hereby submit to you the following report:

CLASS WORK, COLLEGE COURSE.

Last spring, at the close of the college year, the curriculum for the agricultural students was revised. By this change much work has been added to our teaching, but the department of agronomy feels that by this change the course is strengthened, and better fits the student for his chosen work.

The students that were graduated from the agronomy and live stock work last spring have returned to the farm, feeling that, with the knowledge gained here, the farm affords the most remunerative work. It is hoped that, with the new course of study, which covers a wider range, a larger number of young men will be educated to take up farming from a scientific standpoint.

The work in soils is not so extensive as it is where a special department of soils is established. Up to the present time we have been able to teach only the rudiments of "soils." This portion of the work should be strengthened.

The classes in field crops will receive more work this year than in the past. In order to make this more thorough, we should have a small greenhouse. Such a structure need not be more than 10 x 15 feet. The study of the growth of grain, etc., in connection with their classroom lectures, is very essential. The students are not here during the growing season of the grain and grasses, so some substitute should be provided.

COLLEGE REPORT FOR 1908.

The farm management class of senior students has been developed into extremely practical work. Through the kindness of the Denver & Rio Grande Railway Company transportation was given to the seniors, so they were enabled to visit several of the most successful farmers along their route and study methods of farming. Thus, by combining the practical with the theoretical, they appreciate more keenly the value of their education, and they also realize the tremendous field of work that lies before them.

PRACTICAL COURSES.

The practical course work has increased very rapidly. Teaching the short-course students is more difficult than the reg-

ular college students, since in most of the agronomy work text books can not be used. The texts on field and forage crops are not suited for our work, going too much into detail, for which our time is too limited; besides this, most of the material does not apply to our crops under our varying conditions. Likewise, the texts on farm management are not adapted to our State. Nearly all of this is lecture work and discussions, in which the students take great interest.

FARMERS' INSTITUTES.

Whenever possible, and when not conflicting with the regular college work, the writer assists, so far as he is able, in the institute work. This year he has attended thirteen institutes, besides acting as judge of grain exhibits at a number of fairs throughout the State.

Respectfully submitted,

F. KNORR,
Acting Agronomist.

Fort Collins, Colorado, November 24, 1908.

ANNUAL REPORT DIVISION OF ANIMAL HUSBANDRY.

To the State Board of Agriculture:

Gentlemen—I respectfully submit the following report:

EQUIPMENT.

The live stock teaching work has been strengthened by the purchase of Hampshire ewes, and could be made still stronger by the addition of some long-wool sheep.

There is not dairy stock enough available for class work and either Jerseys or Guernseys should be purchased, as recommended in a previous report.

CLASS WORK.

The teaching work was carried very satisfactorily this year; but the new long course, and the practical course present a schedule of teaching which fills practically the entire day, from November until the middle of March. Not over half of the time of the head of the division should be given to teaching, as the correspondence and overseeing of College stock requires about one-fourth of the time, and experimental work one-fourth.

If some farmers' institute work is to be done by this division during the summer, assistance is needed for the entire year, otherwise only during the winter months.

Respectfully submitted,

G. E. MORTON,
Head of Division.

Fort Collins, Colo., November 1, 1908.

ANNUAL REPORT OF DEPARTMENT OF BOOKKEEPING AND FARM ACCOUNTS.

The State Board of Agriculture:

Gentlemen—I herewith submit the annual report of the Department of Bookkeeping and Farm Accounts.

BOOKKEEPING.

At your biennial meeting held in April, 1907, you authorized a one-year bookkeeping course. Since that time very little has been done in the way of advertising this course. Owing to this fact the attendance has been small.

The small attendance is due, largely, to lack of advertising the work and the tuition fee attached thereto. I am strongly in favor of abolishing the tuition and allowing students to register for this work the same as in other courses offered, i. e., free from tuition; also to recognize the course in the way of advertising.

The work for this course, as I have outlined, is the same as the subjects taught in the junior year of the old commercial department and requires high school preparation.

Should you see fit to act favorably regarding my request, I am satisfied you will see a large increase in attendance, besides meeting the approval of many.

FARM ACCOUNTS.

The students in the practical course in agriculture will enter the class of farm accounts early in November, at the opening of the short-course term. Last year I had two divisions in this class and this year, from the present outlook, the attendance will be much larger.

The instruction given is to show the application of the fundamental principles of accounting to the every-day routine of general farming. The system used is simple and practical, one that will meet the requirements of the farmer, dairyman, fruit grower or stockman.

HOUSEHOLD ACCOUNTS.

During the first term of the practical course in domestic science the students take up the subject of household accounts. They are taught how to keep accounts in the home, accuracy in taking care of the receipts and disbursements, and in balancing and proving their work. The use and care of checks, receipts, drafts and notes, etc., are taken up and discussed with good results.

Respectfully submitted,

CHAS. G. DWYRE, JR.

Fort Collins, Colo., October 29, 1908.

REPORT OF DEPARTMENT OF CHEMISTRY AND GEOLOGY.

November 10, 1908.

To the State Board of Agriculture:

Gentlemen—I have the honor to present the following statements pertaining to the Department of Chemistry and Geology:

The instructional work has followed the requirements of the courses as given in the catalogue from year to year. There have been changes in the work, necessitated by changes in the other departments. These changes have, in my opinion, been of doubtful advisability.

I would be very glad to extend the course in chemistry, but I believe it to be inexpedient under the circumstances. The complaint of the students now is that they have not the necessary time to do more. We have endeavored to maintain a fair standard of work in the department, and we believe with reasonable success. The work in general chemistry continues through one year; two terms are devoted to the study of general inorganic chemistry and one term to the organic chemistry. The laboratory work is devoted largely to qualitative work and to such special lines as are required by the other departments.

Geology is studied for one term. We have an excellent suite of rock samples and a good collection of fossils for the illustration of these subjects. Our collection of minerals is limited, and while our samples have some merit as individual specimens, we need a collection of the common minerals which are met with in common rocks.

The short-course work in the department lasts about five weeks, daily recitations. We can only hope that the results of this work are more satisfactory to the students and others than to ourselves. It may be that the time is well spent in doing this class of work, but general chemistry has in the years that we have had this work seemed too specific and difficult for the student to whom it has been presented.

The interior of the building under my charge has been painted since my last biennial report, and its appearance greatly improved. So far as I know, the building is in good repair.

Respectfully submitted,

WM. P. HEADDEN,
Prefessor of Chemistry and Geology.

REPORT OF DEPARTMENT OF CONSTITUTIONAL HISTORY AND IRRIGATION LAW.

The State Board of Agriculture:

Gentlemen--The work of this department since the date of the last semi-annual report requires but brief mention.

The summer vacation was spent in attending the various teachers' normal institutes in the different districts of the State, representing the interests of the college, and making from one to three addresses before each institute. The work required an approximate travel of 5,000 miles within the State.

During the fall term classes have been conducted in agricultural economics and in international law, in the regular courses, and in government and irrigation law in the practical five months' course.

During the winter term there will be classes in advanced history, in political economy, in irrigation law, and in the law of contracts, all in the regular four-year courses.

For the zeal and attention and conduct of the students in all classes I have only words of compliment.

With my acknowledgments to the president of the college, and to each member of the faculty for their constant courtesy, I am, Very respectfully,

W. R. THOMAS,
Professor of Constitutional History and Irrigation Law.

Fort Collins, Colo., November 15, 1908.

REPORT OF DEPARTMENT OF DOMESTIC SCIENCE.

To the State Board of Agriculture:

Gentlemen—I have the honor and privilege of presenting my annual report concerning the work, condition and needs of the Domestic Science Department. It gives me great pleasure to report that the work has been very gratifying in the past year. The continued approval of the students and the public is reasonable assurance that Domestic Science work is being recognized and is regarded as helpful. In presenting these matters to your consideration, it must be said that our work is comparatively new work; and, therefore, real needs exist if there is to be progress in the future.

Our greatest need is a new building. During the past summer this building was thoroughly cleaned. The bath tubs were removed and the bathroom changed into a fitting room. In the basement the walls were repaired, and now with new paper, paint and good walls, the building is clean and attractive.

The heating system is very unsatisfactory, and on cold days last winter it was impossible to heat this building. When working in my office, I had to wear a heavy winter coat and felt the cold very severely. My stenographer and everyone else who was in the office with me always complained of the cold room. The basement is never warm until noon, and, as we have classes there from 7:30 on, it is very hard on the students and the teachers.

During the summer Professor Lory changed the lights. They are now adjustable, and very satisfactory.

The laundry is found to be too small to do good work. I wish that something might be done. We are using the small kitchen to help us out and the wet clothing has to be carried through the long hall, making confusion and a great deal of extra work. If a large room could be secured in some other building, and our old equipment used, the expense would not be great. The present laundry could be used as a cold storage room, as we have no place in which to keep our refrigerator and supplies.

Last June eleven girls were graduated in the two-year Normal Course; three in the General Science Course, and four girls were graduated in the Short Course. This year the attendance is only about one-half of what I expected, but I be-

lieve it is due to the publicity given to our college this last summer. The following students are now enrolled for this year:

Freshman	10
Sophomore	3
Special	7
First Year Short Course	17
Second Year Short Course	8
General Students	5
Graduate Students	1

The Normal Course was taken out last year, and also the Sub-Freshman class, which accounts for part of the loss in attendance. On account of change of courses two years ago, there are no Juniors or Seniors this year.

The one-week Short Course work in Domestic Science is growing rapidly. Last year there were three Short Courses held in various parts of the State and this winter there will be ten. In my opinion, this is the very best way of helping rural districts and small towns. It is practically taking the college work to these women who are unable to leave home and who are anxious and eager to learn the most modern methods of housekeeping. About eighty women registered for the Short Course held in Fort Collins last January. Requests are coming in every day asking for the date of the next one. Circular letters are to be sent out and we hope to have a splendid program for the week's work. Great interest seems to be taken in Domestic Science all over the State. At the Farmers' Institute work during the summer it was a real pleasure to address the gatherings of men and women as they seemed to think our work was not foolish, but of real practical help. Miss Brush and Miss Boswell assisted in the Farmers' Institute work this summer. Miss Margaret Ross and Miss Edna Pughe, two of last year's Normal graduates, have been secured to assist us in the Short Course work this winter.

Miss Crawford resigned last spring to accept a position in the University of Wyoming as instructor in Domestic Science. Miss Inga Allison, of Lake Erie College, was appointed to take her place. She is very capable and will be a great help to this Department. As far as I know, everyone in this Department is working in the greatest harmony, and each teacher is doing her best to uplift the work and to keep up a high standard.

I wish to ask for fifty dollars per year for my department, to be used at my discretion and to be placed at my disposal by January 1. This money will be spent carefully and an account of every cent rendered at the end of the year. It could be called an emergency fund. This would include the purchasing of extra groceries, sewing materials, and utensils, sometimes for extra

work such as having a woman come in for a day to launder the curtains and fine linen or to do housecleaning before school opens after a vacation.

Many requests for help have come from the club women of the State. About twenty outlines for club study have been sent in answer to these requests. I have been trying to get the club women interested, as I feel that it will be through them that we can get the work put into our public schools. I have been trying to work in this vicinity and have succeeded in inducing the Woman's Club of Windsor, and the Woman's Club of Fort Collins to give one-third of the year to Domestic Science. In other cases a few days will be given during the year. Last year I gave talks on Housekeeping at Colorado Springs, Denver, Windsor, Loveland, Fountain, Greeley, Pueblo and Fort Collins. During the year a physician and a trained nurse gave several lectures to our students. Mrs. Sarah Platt Decker, of Denver, gave a splendid talk to the students in April.

The National Federation of Woman's Clubs has done this College the honor of appointing me a member of the Domestic Science Committee, and the State Federation has made me chairman of the Domestic Science Department. At the meeting of the Federated Clubs in Colorado Springs, several people from other States asked about the Short Course work in Colorado. One woman who was there from Cincinnati, Ohio, invited me to give a week's Short Course in that State, but it was not possible for me to do so. I feel that the Short Course work is very important and very helpful.

Mrs. Guldlin, of Fort Wayne, Indiana, who is chairman of the Domestic Science Department of the National Committee writes me that she will put our work before all the women in the United States in the next two years, as she thinks the Short Course program of this State better than any other. I mention this because I think our State Board should know what we are trying to do. There is much to be done and it will take years to do it.

Last January at the State Teachers' Association meeting in Denver a Domestic Science Section was formed and we hope through this means to get the teachers of the State interested in the work. The officers have given us two mornings at the meeting in December, and if these meetings are successful we will soon have the work in many places in the State. In this way through the teachers of Domestic Science we will come in touch with high-school pupils and thus increase our enrollment.

The Foresters who took the Short Course last year asked for some special lessons in camp cookery and the request was granted. Last winter four lessons in camp cookery were given to a class of twenty-five of the College boys.

A donation of a fine gasoline mangle has been made to the Department by the American Ironing Machine Company. Pro-

fessor Lory has installed a fine electric stove. In this way we are able to teach the girls how to manage institutional or hospital work. I am glad the library is to be open evenings during the Short Course, and wish that it might be open the whole year, as the evening is the only time when students and teachers can get much benefit from the books.

The Science Association meeting was held here in the spring. Our students gave a luncheon to the visiting students and teachers, which was very much appreciated.

The Domestic Science Department got out a Domestic Science Special "News Notes" in April. This has been widely circulated and hundreds of requests have been received in this office for a copy of it.

The Theodosia Ammon's Memorial set of books were received in March and placed in the library. The books are used daily and will be a beautiful memorial for many years to come.

The physical culture classes are progressing nicely and it is to be hoped that some provision may be made whereby baths may be put into the gymnasium dressing room.

A dormitory is desirable.

During the year an outline of thirty lessons in Domestic Science for rural teachers was prepared and printed. Copies are sent free to any teacher in this State and on payment of a fee of twenty-five cents to teachers of other States.

I regret exceedingly that on account of a Short Course week at Del Norte and two lectures at the Corn Exposition in Omaha during the second week in December it will not be possible for me to entertain the State Board of Agriculture at luncheon until the spring meeting.

The things asked for in this report are most conservative, based upon real needs, and I commend them to you for your favorable consideration.

Respectfully submitted,

MARY F. RAUSCH.

REPORT OF DEPARTMENT OF CIVIL AND IRRIGATING ENGINEERING.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit my report as Professor of Civil and Irrigation Engineering for the current year.

The crying need of the Department at present, as it has been for some years past, is for a suitable building. For many years we have outgrown the present building, and the pressure for room has been so great that it has been necessary to dismantle some of our apparatus, and to adjust ourselves to the quarters, such as they were. This has meant a curtailment of the work we have felt was desirable to do for the students, and has prevented us from doing many other things which we believed were desirable and would be of benefit both to them and to the State. The need for this has been recognized by the Board.

The Legislature of 1903 made an appropriation of $40,000 through the efforts of the Senator from this district, Hon. W. A. Drake. After the bill was passed the contract was let and excavation made and some of the foundations put in when it was determined by the State Auditor that the revenues of the State were such that the appropriation could not be paid. In consequence the work had to be suspended, and thus it has remained for nearly five years. In the meantime there have been some revenues collected by the State Treasurer which were credited to the revenues of 1903-4, with the result that about a year ago this fund was credited with about $15,000 which was available for carrying on the work. This amount was too small to complete the building as planned, and it was a question how it could best be used in connection with the original plans. To change the plans so as to make a building that could be completed within this sum would not materially relieve the Department, and it was considered by all means best to retain our original plans and to build as much of the proposed building as possible. The amount was not sufficient to inclose the proposed building, but through the aid of additional funds set aside by the State Board of Agriculture, a contract was let which would enable the building to be inclosed, omitting some external parts which could afterwards be added, and omitting all interior finish.

This building as planned is 60x120 feet in extreme dimensions, consisting of two ends of the full width of 60 feet, and connected with an inner portion of 40 feet in width. It provides an assembly room large enough to seat 200 persons on the sec-

ond floor, with several class rooms that will seat as many as 50; a large room adapted for exhibits of irrigation and engineering apparatus, with office rooms for the Department, also an hydraulic laboratory fitted with an hydraulic tank, in which to carry on laboratory experiments; drafting rooms, and general facilities for instruction, together with additional rooms for use in connection with the Experiment Station.

During the existence of the Department a large amount of very valuable data has been collected, and it has been always a cause of apprehension that fire might destroy the records that have thus accumulated, and which would be impossible to replace. Their value is more than of ordinary scientific interest. They have already proved of great value, for instance, in the attack on the irrigation of the State by our neighboring State of Kansas, when the accumulated knowledge and records of this character had a great deal to do with the success in protecting the interests of the State.

The new building is of white brick and will be an ornament to the grounds, and one which we can look to with great satisfaction.

The need of the Department is to finish this building so that we may occupy it at the earliest possible date. By finishing this it will relieve the building which we now occupy so that it may in turn be used to relieve some of the pressing needs of other departments which have outgrown their present quarters.

The present plans of the building were made when a central heating plant was in contemplation, so that there is no provision for its heating. It was thought that a structure, temporary or permanent, as the case may be, could be built back of the building, at a cost less than would be required to change the plans of the present structure and to include a chimney. The appropriation ought to be enough to complete the building and to equip it. The equipment calls for the furniture for the offices, lecture rooms, cases in the museums, hydraulic tank and standpipes, and various other hydraulic and engineering laboratory apparatus, so that the total amount required for this would be $40,000 to $50,000; the smaller sum would not be sufficient to completely do so.

In some previous reports I have called attention to the line of usefulness for the Department and College by instruction in roads. This would be a natural supplement to the work that is being done. There is considerable need, and some organized desire for instruction of this character. A systematic course of study in roads is worthy of consideration. An instructor could be provided at an initial cost of from $1,200 to $1,500 per annum, with some equipment, meaning a total annual cost at present of from $2,000 to $3,000. Such an instructor is needed in the College and in the Institute work, and should be provided for in the near future if it is not considered timely at present.

The general work of the Department has proceeded with a fair degree of satisfaction. The principal difficulties have been those connected with small quarters and the necessity of adapting the work to the current situation.

The Field Camp, which has become an important feature of our work, and a very important element in the instruction of the students in engineering, was this year taken to Pike's peak. Through the courtesy of the mayor and council of the city of Colorado Springs we were permitted to use their building at Seven Lakes as the headquarters of our camp. It is at an elevation of 10,900 feet. With this as a center, surveys were made of existing reservoirs and proposed reservoirs in that vicinity. Besides that there were extensive engineering works within a moderate distance. The reservoirs of the city of Colorado Springs; reservoirs of the Pike's Peak Power Company; the power house at Skagway; the mines at Cripple Creek and Victor; the cog road up Pike's peak, and numerous other important structures within a moderate distance. The camp was pronounced one of the most successful we have ever had, at least in that respect. The cost was also less than the camps of the past few years, principally because of less teaming being necessary, and also because of a systematic effort to keep down some of the expense of the commissary.

Students have shown a commendable interest in nearly all of their work. The record of the graduates has been very good and gives increased satisfaction in their success. The Department has felt first that it was important to turn out men who were good citizens and who would be an element in their communities. In addition, it has endeavored to turn out men of such skill that they would be sure of support, and to give them such an outlook upon methods of engineering that with opportunity they would be on the road to acquire skill and ability. The record of many of the graduates was given in the last printed report. It did not include all. The list could be extended with names and with the creditable work of others. The graduates have made their mark in irrigation and hydraulic work in many enterprises which relate to the development of the West.

Respectfully submitted,

L. G. CARPENTER,
Professor Civil and Irrigation Engineering.

L. G. Carpenter,

Professor Civil and Irrigation Engineering.

Dear Sir—I submit herewith the following report of my work in your Department for the year ending December 1, 1908:

During the months of December, January and February I traveled over the State and visited all the high schools, and many of the lower grades, inspecting the work done in the different schools, addressing the student body at each place upon the merits of the Agricultural College, work done here, and the advantages one secures by coming here. This trip is what we call the high school trip, and is the one that has been taken by Prof. J. W. Lawrence heretofore.

Returning to Fort Collins about March 4, I had charge of the following classes during the spring term:

Senior class in hydraulics. There were nine students in this class and all did good work.

Sophomore class in agricultural hydraulics. There were fifteen students in this class and the work done was acceptable.

Sophomore class in irrigation engineering. This class was made up of seventeen students, and was fair. The class seems to be weak in many ways, and their work with me in irrigation engineering shows a number of failures and conditions.

The sophomore class in drawing met in the afternoon and they covered practically the same ground that has been covered by all classes in this course.

I also had charge of the junior class in drawing for one-half of the term.

During the summer months I spent the time as a member of one of the institute squads, and together with Dr. Glover, Prof. Cottrell, Dr. Newsome, and others, we held Farmers' Institutes for about eight weeks.

The first two weeks of this term were spent in Field Camp at Seven Lakes, about twelve miles west of Colorado Springs. The work consisted of the survey of a reservoir storing the waters of Beaver creek, the seniors having charge of the dam site survey and also the topography of the reservoir. The high water line contour was run by the juniors and sophomores. Surveys were also run for reservoirs No. 7 and No. 8, lying further up in the mountains. We also took occasion to visit the different points of interest in this region, going over the entire Cripple Creek district and also inspecting the engineering works already completed in the Seven Lakes district.

The classes taught during this term are as follows:

Junior class in hydraulics. There are twenty-eight students in this class, and the work as a whole has been poorly done.

Senior class in meteorology. The thirteen students in this class have done acceptable work in every way.

Twelve students in the photography class have also done good work.

At the present time I am giving to the second year short-course students lectures on the principles of irrigation. This class has twenty-six students in it, and all seem to be greatly interested in their work.

The afternoons have been spent with the junior class in hydraulic laboratory. We spent the first part of the term rating meters at the College lake, after repairing the damage done to the station last winter by the ice. At present we are at work rating the streams in this vicinity, and will continue on this line of work throughout the remainder of the term.

Respectfully submitted,

E. B. HOUSE,
Associate Professor of Irrigation Engineering.

REPORT OF DEPARTMENT OF ENGLISH.

To the State Board of Agriculture.

Gentlemen—In the main, the work in the Department of English is being carried out as outlined in the catalog. In addition to the regular work we have two students taking sub-freshmen English, and one student, a junior, taking special work in grammar.

At present we have the following classes:

	No of Students.
(1) Class in Sub-Freshman English	2
(1) Class in Special English	1
(3) Classes in Freshman English	87
(1) Class in Sophomore English	15
(1) Class in Senior Logic	13
(1) Classes in Parliamentary Practice and Citizenship	19
(3) Classes in Practical Course English	46
Total (11) Classes	193

Miss Carscadden, a graduate of the University of Nebraska and a teacher of experience, is first assistant in the department. Mr. Iddings, of the Agricultural Department, has kindly consented to take the work in Parliamentary Procedure and Citizenship, and Miss Baker, a graduate of the University of Colorado, is helping correct themes.

The Practical Course students in English have been divided into three divisions based upon their present efficiency in English, and not upon grades from other schools attended. A student will be promoted from one class to the next higher as soon as he is worthy of advancement. "It is up to the student."

We are pleased to note that the library is now open in the evening. Heretofore, the students in our department have complained that they have had no time to do work in the library.

The most efficient work in the department would necessitate additional help.

Respectfully submitted,

B. F. COEN,
Professor of English.

November 14, 1908.

REPORT OF THE DEPARTMENT OF FARMERS' INSTITUTES AND COLLEGE EXTENSION WORK.

To the State Board of Agriculture.

Gentlemen—The Farmers' Institute and College Extension Work for the year ending November 15, 1908, has been as follows:

	Attendance.
128 Farmers' Institutes	20,285
7 Special Meetings	600
28 Train Institutes (1,583 miles)	5,005
12 Farmers' Short Courses	1,401
3 Domestic Science Short Courses	1,034
Total	28,325

The total number of sessions at all institutes was 240, and the total attendance at all sessions was 33,605. Forty speakers connected with the College and thirty-three from outside took part in the work. The expense for the year was $7,886.33.

In March, 1908, the Denver & Rio Grande Railroad furnished free to the College a Potato Institute train of four cars and ran the train over 1,583 miles of their track. The baggage car contained all the implements and equipment needed for growing potatoes in Colorado. Three passenger coaches were used for seating audiences to hear lectures on potato growing. The College sent seven lecturers on this train. It stopped at 23 towns, and 28 meetings were held attended by 5,005 people. The result was a large increase in the acreage planted to potatoes in the territory covered by the train. F. A. Wadleigh, Assistant General Passenger Agent of the road, accompanied the train and aided very much in extending its usefulness.

In June, 1908, F. S. White, Agricultural Commissioner of the Rock Island-Frisco Railroad, invited the College to hold Farmers' Institutes along the Rock Island Railroad in Colorado, working in connection with him. Institutes were held in eleven towns, the lectures being given in halls. Following the lectures, the audience visited the exhibition car of the Rock Island-Frisco System.

All the railroads except the Burlington and the Missouri Pacific have given our lecturers free transportation to attend Farm-

UNIVERSITY OF CALIFORNIA

ers' Institutes and this aid has enabled us to double the number of meetings we have been able to hold with our appropriation.

In 1907, Prof. Wendell Paddock held at Delta a week's Short Course in Fruit Growing, the first Short Course held in the State outside the College. It was so thoroughly appreciated and such a marked success that it was decided to have the Farmers' Institute force spend the winters in holding Short Courses, adapting each course to the special needs of the locality in which it is held.

From January to March, 1908, there were held at places outside the College twelve Farmers' Short Courses with a total enrollment of 2,435. Each Farmers' Short Course was held for six days and each Domestic Science Short Course for five days.

To secure a Farmers' Short Course 100 subscribers were required, each paying a fee of two dollars, and fifty subscribers at one dollar were required for a Domestic Science Short Course. These fees paid about half the expense to the College.

The Short Course is the most thoroughly appreciated and the most valuable extension work done by the College. It permits the giving of extended information on subjects of special importance to those who attend.

A readjustment is necessary in the Farmers' Institute and Extension Work of the College. The members of the Experiment Station and College forces feel that in justice to their other work they must reduce very materially the time spent in Institute and Short Courses. At the same time to meet the needs of the farmers of the State more than double the number of Farmers' Institutes should be held with at least seventy-five Short Courses each year, and new lines of work are urgently needed.

In the past two years many thousand farmers have come to the State. Most of them are unacquainted with the conditions and methods that secure the best results in Colorado. They need help from the College. If they succeed, they bring thousands of other settlers to the State. Their failure means a permanent injury. For the benefit of the State, the College should hold a Farmers' Institute in every settlement where new settlers are numerous.

There were held during the year all the Institutes which the funds would permit and that with the free help of the faculty. With the instructors of the College finding it necessary to do less Institute work, more outside help will have to be employed.

Our appropriation was exhausted early in September and there have been many requests for Farmers' Institutes that had to be rejected on account of lack of funds, and a good part of the State has not been sufficiently covered. In the three northwestern counties of the State no Institutes were held because there was no money. These three counties have an area one-half

greater than Massachusetts, and when properly farmed will become one of the most productive sections of the State. In those sections of the State where Institutes were held there were not funds to hold a sufficient number, e. g., there are 70 stations on the lines of the Union Pacific Railroad in Colorado and many settlements off the railroad where Farmers' Institutes are needed. We were able to hold Institutes at but 12 places in all this territory.

Besides the additional work needed in Farmers' Institutes and Short Courses, the Farmers' Institute Department should take up two lines of work that have proven very efficient in promoting Agriculture in other States—Correspondence Courses in Agriculture and Boys' and Girls' Clubs.

There are thousands of new settlers on Colorado farms who need information throughout the season on problems that come to them in the new conditions under which they are working. Such problems as preparation of the soil and varieties to plant at different altitudes, when and how to apply water, methods of culture, how to feed Colorado crops, and prevention of insect depredations and plant diseases. Besides specific information they need to be taught the principles underlying farm methods peculiar to Colorado. A Correspondence Course fills this need and can be adapted to the special wants of each farmer.

There are more than 60,000 boys and girls over 14 years old of school age in Colorado. The Farmers' Institute Department should organize these boys in school districts and township clubs to grow grains, potatoes, sugar beets, melons and field peas, to feed Colorado crops and to study methods and markets. Each year a Boys' Institute should be held in a township at which the products grown by themselves compete. The prize-winning products of each township should compete at a County Institute and the winners in each county should enter a State Contest. Similar work should be conducted in cooking and sewing with the girls.

The Boys' and Girls' Clubs would not only enthuse the members in developing the agriculture of the State and give them valuable training, but it would have a strong influence in the same direction on their parents.

The expenses for the work of this Department last year were $7,886. With less help from the Faculty there will be needed the equivalent of the time of two thoroughly trained men all the year. This will cost at least $3,600, or a total of $11,486. If $25,000 is appropriated for the coming two years, it will furnish only $1,000 a year to extend the old work and to start the new work needed. Double the amount could be expended with profit to the State.

Respectfully submitted,

H. M. COTTRELL.

FARMERS' INSTITUTE AND COLLEGE EXTENSION WORK

For Year Ending November 15, 1908.

	College Staff	Farmers' Institutes	Special Meetings	Train Institutes	Short Courses	Total
1	Dr. R. W. Corwin.....	..	..	..	1	1
2	Hon. E. H. Grubb.....	3	..	28	4	35
3	President Aylesworth.....	..	..	..	9	9
4	F. C. Alford	13	..	..	..	13
5	H. M. Bainer	17	..	..	..	17
6	E. R. Bennett	32	1	28	8	69
7	P. K. Blinn	7	..	..	1	8
8	H. B. Bonebright	3	..	..	..	3
9	Rebecca Boswell	7	..	..	..	7
10	Emma Breining	..	..	..	3	3
11	Mary J. Brush.....	5	..	..	..	5
12	L. G. Carpenter	1	1	..	5	7
13	W. L. Carlyle	5	1	..	2	8
14	H. M. Cottrell	57	1	28	10	96
15	Elizabeth Cutler	..	..	..	1	1
16	Marguerite Frink	5	..	..	..	5
17	R. W. Gay	..	..	..	1	1
18	C. P. Gillette	10	..	..	10	20
19	G. H. Glover	8	..	..	4	12
20	W. P. Headden	1	1	..	6	8
21	E. B. House	21	..	..	2	23
22	E. J. Iddings	7	..	..	..	7
23	S. A. Johnson	15	..	..	..	15
24	H. E. Kingman	3	..	..	..	3
25	Fritz Knorr	13	..	..	..	13
26	B. O. Longyear	1	..	..	..	1
27	C. A. Lory	5	..	..	..	5
28	G. E. Morton	20	..	..	4	24
29	I. E. Newsom	11	..	..	..	11
30	W. H. Olin	6	1	..	..	7
31	W. Paddock	14	1	..	7	22

32	L. F. Paull	8	..	..	1	9
33	R. B. Parshall	8	..	..	..	8
34	Mary F. Rausch	8	..	..	5	13
35	W. R. Thomas	..	..	..	1	1
36	J. F. Tuttle	..	..	..	3	3
37	Geo. P. Weldon	2	..	..	..	2
38	Echo Ward	..	..	..	2	2
39	O. B. Whipple	14	..	..	5	19
40	Hon. F. E. Brooks	1	..	..	..	1

FARMERS' INSTITUTE AND COLLEGE EXTENSION WORK.

For Year Ending November 15, 1908.

	Outside Speakers	Farmers' Institutes	Train Meetings	Short Courses	Total
1	E. M. Ammons	1	..	4	5
2	B. G. D. Bishopp	9	..	..	9
3	E. R. Bliss	..	28	5	33
4	Prof. W. G. Chambers	1	..	..	1
5	J. H. Crowley	2	..	..	2
6	Sam Doll	..	28	..	28
7	J. W. Downey	8	..	2	10
8	H. L. Edgerton	..	26	..	26
9	C. L. Fitch	2	..	1	3
10	E. J. Foreman	1	..	2	3
11	Robert Gause, Jr.	..	..	1	1
12	F. Gaylord	..	..	1	1
13	J. A. Girardett	1	..	..	1
14	Chas. Green	..	..	1	1
15	O. C. Gregg	2	..	6	8
16	Gov. E. R. Harper	..	..	8	8
17	J. H. Johnstone	1	..	..	1
18	Anna Kihme	..	..	3	3
19	G. W. Martin	..	..	1	1
20	H. W. Moore	1	..	1	2
21	C. F. Mason	7	..	..	7
22	E. Matthews	..	..	3	3
23	H. F. Palmer	..	..	1	1
24	J. E. Payne	1	..	..	1
25	A. R. Pierce	3	..	..	3
26	C. H. Rhodes	7	..	..	7
27	I. Rothchild	1	..	..	1
28	E. Sherman	..	21	..	21
29	A. T. Steinel	1	..	..	1
30	E. Smith	..	..	2	2
31	W. G. M. Stone	..	..	8	8
32	W. H. Vassar	2	.	.	2
33	F. S. White	11	..	..	11

DEPARTMENT OF FARM MECHANICS AND DAIRYING.

To the State Board of Agriculture.

Gentlemen—I hereby respectfully submit the following third annual report of the Department of Farm Mechanics and Dairying:

Early in January Mr. H. B. Bonebright was secured as Assistant in Farm Mechanics and Dairying to fill the vacancy made by the resignation of Mr. W. G. Hummel.

During the past year eight classes have been taught in lecture room work, and eight classes in laboratory work. This includes work given in both the four-year course and the Practical Short Course. During the present term we are giving instruction to four classes in lecture work and three classes in laboratory work.

Twenty Farmers' Institutes have been attended during the year by members of the Department.

At one time last winter it became necessary to give instruction work to fifty-five Short Course students at one time. Under these conditions it became necessary for us to divide the class into two sections, and to give the instruction in two different places at the same time. Our class room is entirely too small to handle as large a class as this at once.

Very little additional machinery has been secured during the past year on account of not having room in which to store it. During the past summer an addition 36x66 has been erected to the south end of the Farm Mechanics' Building, and we are now very well equipped with storage room. Our present Farm Mechanics' Inventory shows a valuation of $11,275.00, and the Dairy Inventory shows $1,150.00.

Considerable correspondence has been carried on during the year on both Farm Mechanics and Dairy subjects. Some experimental work has also been carried on by the Department.

Respectfully submitted,

H. M. BAINER,
Professor of Farm Mechanics.

Fort Collins, Colo., November 1, 1908.

REPORT OF DEPARTMENT OF HISTORY AND LITERATURE.

To the State Board of Agriculture.

Gentlemen—I have the pleasure to submit herewith the annual reports of (1) the Department of Literature and History, and (2) of the Dean of Women.

The regular scheduled class work, which includes five courses offered in history, and five in literature, has been conducted during the past year, and in addition to this, a course of lectures in American History has been given for the girls of the second year in the five months' practical course.

The industrial history of the United States has been introduced as an appropriate addition to the Agricultural and General Science Courses, this branch being taught for the first time this year.

At the beginning of the fall term the dormitory, which has been the only home for college girls under college control, was abandoned, and I was asked by the President to secure homes for the girls in private families, and to provide plans for the same college supervision for all. By the assistance of Miss Carscadden, who is able to relieve me of a part of my class work, I have been able to devote the necessary time to this work of the supervision of the interests of the college girls. The following general regulations have been found desirable, and have been adopted with the full co-operation of the lady teachers and student girls:

(1) No women students are assigned rooms in houses where any rooms are rented to men students.

(2) Gentlemen company is allowed only in the parlors, and never in private rooms.

(3) Company is allowed in student boarding houses only on Friday, Saturday or Sunday evenings, not on the evenings of regular school days, and not later than ten o'clock, excepting by special arrangement.

(4) Chaperones are required for all parties given by students.

(5) In general the young women are encouraged to exercise their own good judgment with regard to matters of conduct, and to be considerate of the rights of others in the homes where they are received.

Many of the best homes in Fort Collins have been opened to students under this plan, and most of the girls board and room at the same place. I have, by frequent visits in these homes, received very satisfactory reports regarding the home life of our student girls. We have at present as fine a class of young women as has ever been enrolled at C. A. C. One hundred and three is the total enrollment to date in all departments.

The Lecture Course, conducted for the last five years in the interest of the social needs of our young women, has been arranged for this year, as usual, to consist of five members. In addition to these five special entertainments an hour or so for social intercourse has been secured, by the co-operation of other departments, on the first Thursday afternoon of each month. The lady teachers, and often the wives of faculty members, join with the girls in these gatherings.

It is believed that wholesome College spirit, and devotion to C. A. C. ideals and interests will be fostered by these plans.

Permit me now to call attention to some of the needs of student girls:

(1) More adequate representation of their interests in our faculty councils.

When I entered the faculty there were fourteen members, two of them women, or about fourteen per cent. of the entire number. Since that time, by the action of your honorable body, the faculty has been increased by fifteen additional members, all of them men, making a total of twenty-nine who were listed in the last catalogue, so that the proportion is now but two women members in a faculty of twenty-nine. During a part of the year, the demands of the extension work leave me the only representative in the faculty councils of the particularly feminine interests of the College. I earnestly request that Miss Kettle, who has been for the last four years the head in fact of the Department of Modern Languages, be recognized as a member of the faculty, and so be given an opportunity to join in our deliberations upon matters of College policy.

(2) Better accommodations in connection with gymnasium work.

We require of every girl three hours per week in the gymnasium, but provide no decent facilities for the dressing room. The water and sewer pipes are already in the room used for this purpose, and at a trifling expenditure several wash bowls and appropriate partitions to provide privacy in the dressing room could be secured. Shower baths would also be desirable, but provision for water in some form is imperative. Our lessons in personal hygiene are contradicted in practice every day. I most earnestly urge the attention of the Board to this matter.

I would also ask you to confirm by your action my appointment by the President as Preceptress of Women, and to increase

my salary by an amount in proportion to the additional responsibility which I have been asked to assume. I have served the College for eight years, and during that time have had the pleasure of rejoicing with some twenty of the others of the faculty who have been encouraged by an increase in salary. Only five of the twenty-nine members of the faculty, besides our President and Secretary, have had a longer term of service than mine, and I feel that upon assuming the additional duties which I have been urged to accept this fall, my salary should certainly be increased to $1,800.

During the past few years I have been making a study of the conditions for women in the agricultural colleges of our country, and the opportunities they offer for women students. You may be glad to know that the work I have done along this line has been accepted by my Alma Mater at Ames as a thesis, and that the degree of Master of Philosophy was conferred upon me at the commencement last June.

I am always glad to acknowledge as a direct benefit to my Department any extension of library facilities. The recent provision for evening opening is a great accommodation to my students, and I trust that the plan may be continued.

Respectfully submitted,

VIRGINIA H. CORBETT.

Fort Collins, Colo., November 15, 1908.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND BOTANY.

To the State Board of Agriculture:

Gentlemen—I have the honor to present the report of the Department of Horticulture and Botany for the past year.

The instruction in the Department has been given according to schedule and the interest on the part of both students and instructors has been good. Your attention was called to the fact in a former report that a change in the course of study was desired. This change has been accomplished, much to the benefit of all concerned, as we are now able to give more specialized work along the lines which the student may elect.

The Department never was in so flourishing a condition as at present. More students have enrolled for the course than ever before, and there is little that we need in the way of equipment, outside of greenhouses, that can be provided.

Mention was made in the last published report of preparations which were making for a fruit growers' short course at Delta. This course proved to be a great success, and the movement has taken a hold on the people, under Professor Cottrell's direction, so that now more calls are received for these courses than can possibly be met. We have been glad to give our time to help get the College extension work well started, but the time is now at hand when other arrangements must be made. Indeed, the demands on our time, both summer and winter, have been so great that experiment station work has been neglected. Possibly this result is inevitable, as the executive work and correspondence of the Department are assuming large proportions.

Respectfully submitted,

W. PADDOCK.

THE LIBRARY.

Fort Collins, Colorado.

To the State Board of Agriculture:

Gentlemen—The following report, concerning the College Library, is respectfully submitted:

The report is arranged under five heads: Functions, Equipment, Maintenance, Miscellaneous and Statistics. A general statement and description may be found in the annual catalogue and in previous reports.

FUNCTIONS.

The Library of this College is a general service office and not like a department. The service is to all departments and all the College.

This College is a technical institution, offering courses in the various phases of the subjects grouped about the soil and its products, a limited scope of engineering, domestic science, industrial sociology and the current, local student interests. We require a scientific library of reference and research, and our policy is plainly an intensive collection of books in direct response to our College environment. Our specialties (arranged alphabetically) are agriculture, domestic science, engineering, horticulture, industrial sociology and statistics, and public health and welfare. Subjects such as botany, entomology, history, language, literature, veterinary medicine, etc., are included or are contributory.

In addition, we have to assume, in part, the functions of a public library, because there is no large public library near us. The current student interests, including literary and debating societies, require books and service, and there is actually no limit to the student and public demand made upon a comparatively large library situated as this is.

Both for the sake of prestige and service, this Library must be notable as an intensive collection rather than a mass of nothing in particular, resembling hundreds of other inconsequent collections. This should be a scientific Library of reference and research within our specialties, and this report is devoted to an emphasis of that point of view.

We are one of four or five libraries in Colorado that rank higher than the others in size, equipment and service. We can hold that rank only by performing our intensive functions with whatever of maintenance we may have. We are just approaching

a knowledge of our functions, and this particular statement is put forth now because we stand upon the threshold of our library activities and at the beginning of library history in Colorado. Our progress and success depend upon careful plan and policy of an intensive collection liberally supported.

In the nation this Library is one of several similar libraries, many of which are perfunctory and of little service through failure to appreciate the importance of definite functions. On the other hand, there are those that understand this matter so well that they have skimmed the cream of our specialties (and other specialties) while we were idle or without means. This is true in the literature of irrigation, the history of agriculture, and in every department under the heads given in the alphabetical list at the beginning of this topic. This is going on all the time and grows more intensive and permanent as institutions increase their efficiency and responsibilities demanded in modern life. It is surprising to discover the real extent of this rivalry in collecting special material in our own lines.

In brief, our functions are plain enough, and a detailed statement is superfluous. It remains with us to provide for a collection in response to the present demands and to project the efficiency of this Library into the future of the College, so wonderful in its educational promise. We should take immediate measures to collect the history and practice of irrigation and agriculture in Colorado, and elsewhere. We shall have to go to market for nearly everything, and the sooner the cheaper.

EQUIPMENT.

Our book collection, in some part, has been in storage for seven years, because we have insufficient shelving, inadequate floor space or some similar want to hinder service and retard growth. Library progress must sit and wait for long periods while equipment crawls up to our station point. We have tons of material unavailable, and our reading room space is so cramped that something should be done for student accommodation. Our equipment is far behind our service. The inventory of the Library shows a value of $40,000; it is desirable to have such a collection in a fire-proof building.

DOCUMENTS.

We have a very valuable collection of documents of the United States. It is probably second to none in the Rocky Mountain region, and, as a collection, it is unusual in the West. We have spent a great deal of time on it and one portion alone (U. S. Dept. of Agriculture and the State stations) is worth $2,000. Our designation as a document depository is but three years old in effect.

Our serial set of congressional documents in sheep binding lacks only 300 pieces (out of 5,200) of a complete set, and we

have practically completed several "departmental" sets, notably, the Smithsonian Institution and U. S. Geological Survey. The fortunate conditions which have enabled us to make these collections are not likely to recur and the value of such material increases as the book market is cleared of documents.

We should make immediate plans for similar collections of the documents of separate States and foreign countries before it is too late. We should have official documents of engineering and public works of cities, States and nations; official documents on public health and vital statistics; on labor and the laboring classes; the reports of boards of agriculture; reports of special commissions covering many subjects from rural life to manufactures, from temperance and charities to technical education, as they touch our lines. A reference library cannot exist without official documents and research is impossible without them.

In the case of irrigation literature, a list of ditch and water companies should be made for purpose of correspondence. We should collect official information that is not now in print and probably never will be until some library collects the material for the research worker. All this document work should be pushed to a comprehensive stage so that check listing may be begun at once.

Our collection of documents is worth $10,000 at a low estimate and it has cost us very little: We are about to begin the difficult and expensive part of that work.

SCIENTIFIC TRANSACTIONS AND PERIODICALS.

We have a few good sets or parts of sets, especially in agricultural chemistry and botany, but we are without many important titles. We cannot take rank as a scientific library until we have given this class of literature more attention in English, French, German and Italian serials and periodicals.

Subscriptions to current serials and their binding costs us less than three other institutions in Colorado, but we are doing all we can do with current funds for maintenance. As for the binding, we have a great deal too much of unbound material and we should make provisions for much of it in pamphlet cases. We are now at work on the design of a new pamphlet case, a little better than anything we know now in use.

Binding costs a great deal of money and it should be faced as an inevitable expense. It costs a great deal of money to conduct any sort of good service, and good binding is an important part of library service.

CATALOGS AND BIBLIOGRAPHY.

We use a dictionary catalog of about 80,000 cards and a catalog of station literature of about 30,000 cards. We have a collection of document catalogs and the representative bibliographies.

All things considered, we have an excellent beginning, and this department of the service is growing rapidly. We have to thank our purchasing for intelligent support of this indispensable equipment.

FIRST THINGS NEEDED IN EQUIPMENT.

We need shelf room, floor space, desk and office equipment and what is generally known as "room to turn around in."

MAINTENANCE.

The librarian does not forget that the problem of the whole institution is larger than that of the library. The duty of the librarian, however, is to state his case with the library in mind.

The rate of increase in library maintenance is nearly fourfold in seven years, and, although we are behind our neighbors in maintenance, that is all a librarian can expect. We realize the difficulties in the growth of the institution and we are thankful for constant help as far as the money will go.

Because of an increase, we are enabled to keep the library open five nights each week for five months and in several other ways to make the library more and more a general service office. We are in actual need of larger maintenance in order to meet the demands made on our service.

MISCELLANEOUS.

Library instruction—Besides systematic instruction of the student body in the use of library and books, we have a few special students in the library. The instruction includes library science, library economy and library handicraft. We have supplied several librarians and assistants in Colorado and other States. The work is described in the annual catalog of the College. There should be a library school under the direction of the State Library Commission, but until that commission is provided with funds, we shall continue with some duty in the matter. The library situation in Colorado is calling for trained workers.

Correspondence and exchange, information bureau, extension work, donations, and several minor headings must be omitted from this report, but it should be noted that a large part of our donations is due to the recent system introduced by Mr. Wm. L. Post, Superintendent of Documents in Washington, who has done more for us that can be told in a brief report. Mr. Post has worked wonders for all libraries that mean business in document service. We can never give sufficient thanks to Mr. Post and to Mr. Franklin E. Brooks, who gave us our document designation.

SPECIAL COLLECTIONS.

We have now the Annie Jones collection, the Louis B. France collection, the B. O. Aylesworth collection and the Theo-

dosia Ammons memorial collection. All but the last have been noted in previous reports. The Ammons memorial was donated for the Domestic Science Department by the Colorado Federation of Woman's Clubs.

DEPARTMENT LIBRARIES.

This will require a special report, and when the time arrives this matter will prove one of the difficult problems of the College. Department libraries, department apportionments, custodianship and the best form of service for the greatest number are in a hopeless jumble of administration in the college and university libraries of the United States.

BOOKS IN THE LIBRARY.

It is not easy to make an accurate count of books in a library with so little shelving and so many books. Our actual shelf capacity measures (in the main library) about 30,000 and the floor holds several thousand more. If our material were recorded as usual in large libraries we should have a little more than 40,000 volumes, bound and unbound, but not counting pamphlets. The bound volumes in the library increase rapidly as we reduce the unbound and the pamphlets by binding. Our pamphlets have been reduced to 35,000 pieces, but will probably show an increase next year because we have no room for arrangement of pamphlets into volumes for binding.

STATISTICS,

Finances, Inventory, etc., are submitted to the Secretary and are not a part of this report.

I take this opportunity to thank those who have helped in the growth of this library. The recognition of the professional service of the librarian and of the importance of the library in the educational plan is the most gratifying event in our records for the year and will be most influential in the future of the library.

Respectfully,

JOSEPH F. DANIELS,
Librarian.

REPORT DEPARTMENT OF MATHEMATICS.

To the State Board of Agriculture:

Gentlemen—During the past year this Department has done considerably more work than is outlined in the catalog. Classes have been taught in the following subjects: Elementary Algebra, Plane Geometry, Solid Geometry, College Algebra, Plane and Spherical Trigonometry, Plane Analytics, Differential Calculus, Integral Calculus, Solid Analytics and Mathematical Drawing, Elementary Arithmetic, Commercial Arithmetic. The total number of students enrolled in these classes has been 458.

We are making a special effort this year to meet individual needs. Many worthy, hard-working students have a poor faculty for Mathematics, and in consequence either change to a course where Mathematics is not prerequisite or drop out of school. We have sought these out, and by special appointment daily have given them such suggestions and encouragement as to materially strengthen their work.

It seems to go without saying that a workable knowledge of Mathematics is the most vital feature in technical education. It has therefore been our purpose to make the Department of the utmost practical importance to both the Agriculturist and the Engineer. To this end we have striven to introduce numerous problems from practical affairs. Miss Frink is deserving of favorable mention in this regard. She has compiled some 125 problems relating to farm life, irrigation, etc., which we are teaching in the practical course in Agriculture.

Regarding my assistants I beg to say there has not been a discordant note during the year. The disposition has been constant devotion to duty. Out of the many hundreds of recitations I can not recall of a single instance in which a lesson has been missed on account of the absence of a teacher.

Permit me to remind you that since my last report five young ladies have elected to take advanced mathematics, and they have been eminently successful in their work. At the present time I am directing post-graduate work in Solid Analytics and in the History and Pedagogy of Mathematics.

Respectfully submitted to the State Board to whom I am grateful for continued courtesies.

S. L. MACDONALD,
Head of the Department.

December 1, 1908.

REPORT OF DEPARTMENT OF MECHANICAL ENGINEERING

To the State Board of Agriculture:

Gentlemen—I have the honor to submit the annual report of the Department of Mechanical Engineering.

The course in Mechanical Engineering as presented at the Colorado Agricultural College is such as is given at the best technical schools of the United States.

The instruction is intended to be thorough, and the equipment is of the very best, care being taken when obtaining apparatus that each piece shall be of the greatest usefulness for its purpose.

Colorado is forging ahead magnificently along industrial lines, and with the development of the vast natural resources within her borders new industrial enterprises are springing up everywhere, while the older ones are becoming more firmly established.

With this industrial growth comes a demand for men competent to solve the problems connected with such enterprises. Young men from the College are in many of these establishments, occupying positions of trust and responsibility.

We are trying, first, to teach the general underlying principles of engineering, then to add as much detail and special technical knowledge as a course extending over four years will permit.

We believe our methods of teaching are in conformity with the best modern practice, and while we are practicing no freak or short-cut methods, we are trying to give our students real, substantial values.

We have a larger number of older students this year than usual, and it is gratifying to note their interest and earnestness of purpose.

The various lines of study seem to articulate very well, and our young men find very little difficulty in putting to practical use the technical knowledge they have acquired while at the College.

The Course in Farriery is patronized to about the same extent as it was last year, and the young men are interested in the work.

The Short Course in Mechanic Arts has a few students who are taking the work, but it will have to be discontinued next

year as the studies in this course are taken from those of the preparatory school, and as the studies can not be given next year, these students can not be accommodated.

While we are doing well with the equipment we have, I desire to outline for your consideration some few improvements which will make for progress and add greatly to the usefulness of the Department.

The Department of Mechanical Engineering, while specifically training students for the work of the Mechanical Engineer, is, at the same time, in many of its divisions of work, training the students of several other departments of the institution. Drawing is taught to the Freshmen and Sophomores in several of the courses, steam boilers, also the several lines of shop work. This requires a large amount of room to accommodate the students in some features of the work, and we have arrived at a point where more room ought to be provided.

The drafting room, the wood room and the forge room are the places where the most pressure is felt, and I make the following suggestions as a remedy for these conditions.

Build a third story upon the north wing of the present Mechanical Engineering building in which a drafting room and class rooms may be fitted up.

Enlarge the present blacksmith shop by taking in with it the foundry room, and then build a new foundry room adjoining the present one.

To satisfy the demand in the wood room the present benches with their equipment should be doubled in number. The requisite number of benches can be put in by crowding them into the room now used as a carpenter shop.

We have no trouble in holding the interest of the students in their work, and the above changes would tend to simplify very much the arrangement of work.

Respectfully submitted,
J. W. LAWRENCE,
Professor of Mechanical Engineering.

November 15, 1908.

The State Board of Agriculture:

Gentlemen—I have the honor to submit the following report for the semi-annual period ending November 15, 1908:

The progressive instruction in infantry drill regulations, as outlined by general orders from War Department, has been carried out as far as possible; lack of a suitable rifle range and limited time allowance prevented the prescribed course in target practice. Lectures bearing upon the subject and also on field service have been given, together with theoretical and practical instruction in signaling. The report of the Military Inspector for the year 1907-8, now on file in the President's office, is the most favorable one yet received. The Battalion at present consists of thirteen (13) officers and one hundred and fifty-four (154) N. C. O's and privates, divided into four infantry companies and band. The figures show a falling off in attendance; however, the present students are larger, stronger and more capable of doing advanced work. The band is furnishing good music, and I believe that it is deserving of all possible assistance and encouragement. The medals and flag so kindly donated by Captain B. F. Rockafellow were the means of stimulating a friendly rivalry amongst the students, and in the final contest twelve cadets entered. Sergt. H. B. Scammel won the gold and Sergt. Victor Cram the silver medal. Company "B" won the flag.

Very respectfully,

H. D. HUMPHREY,
Captain U. S. Army.
Professor Military Science and Tactics.

REPORT OF DEPARTMENT OF MODERN LANGUAGES.

To the State Board of Agriculture:

Gentlemen—The work in the Modern Language Department is noticeably stronger this year, since no student lower than the sophomore class is allowed to take it. Two-year courses in both French and German are offered, and one year in Spanish. The work is obligatory for all but the Agricultural and Veterinary Departments.

It must be understood that this work is not of an academic or classical nature, that it is in harmony with the spirit of this institution, and as scientific and practical as we can make it.

In consideration of the fact that all our work is college work and that there is so much of it that I have had to have an assistant this year, I most respectfully ask for my Department and for my professorship. This is my fourth year in connection with the College (one year spent at the Universities of Berlin and Paris), and I have waited from year to year expecting this Department to be recognized by the Board. It is in no way dependent on any other Department, nor has it been for the last seven or eight years.

If you would be so kind as to give this matter your consideration, I should be most grateful.

Respectfully yours,

SARAH I. KETTLE,
Instructor in Modern Languages.

REPORT OF THE CONSERVATORY OF MUSIC.

To the State Board of Agriculture:

Gentlemen—I beg to report an enrollment of one hundred students for the past year. At present there are five teachers employed in the Department. The growth of the Conservatory has been rapid and consistent. Since September, 1908, to date, we have registered eighty-two students, an increase of thirty-two per cent. over the corresponding period of 1907.

We are greatly hampered in our work for lack of room, and respectfully ask you to investigate our needs, so that we may be in a position to take care of our increasing registration.

Respectfully submitted,

ALEXANDER EMSLIE,
Director of the Conservatory of Music.

REPORT OF THE PHYSICAL DIRECTOR.

To the State Board of Agriculture:

Gentlemen—No improvements have been made and no apparatus has been added to the Gymnasium since my last report.

I again call your attention to my report for shower baths. Good health, cleanliness and convenience make these absolutely necessary.

Since the faculty has ruled that Gymnasium is compulsory, it becomes a crime against cleanliness and common decency to force students to exercise freely without giving them the opportunity to cleanse their bodies. As it is at present there is not even a wash room. Many of our students are at rooming places where it is not possible to take a bath, which makes the need of this equipment for our Gymnasium all the more urgent.

My report last year and also two years ago called your attention to this need. Conditions are becoming more aggravated, and I trust that you will see your way clear to give this matter your prompt attention.

I will gladly confer with any committee you wish to appoint to look after this matter.

Respectfully submitted,

C. J. ROTHGEB.

REPORT OF DEPARTMENT OF PHYSICS AND ELECTRICAL ENGINEERING.

To the State Board of Agriculture:

Gentlemen—The work in Physics is being done according to the schedule of studies of the various courses. No preparatory work is offered, but a class for such work will be organized beginning with the winter term, to help those freshmen who were conditioned or failed in this subject as sub-freshmen last year.

This term we are teaching in all seven classes for a total requirement of twenty-three term hours with a total enrollment of one hundred men. The students are doing good work. They are responding to our stronger requirements for credit with an enthusiasm that is most encouraging, and strengthens the belief that students desire the best the College can give and are quite willing, nay anxious, to do their share of the work. That men do not leave an institution because the work is hard, but because it is of low standard, and that the best way to hold students in school, to make them enthusiastic in their loyalty and firm in their devotion to their alma mater, to weld them into a powerful organization for winning new students, is to set a high standard of scholarship and maintain it at any cost.

The limited laboratory quarters makes the work of instruction difficult and arduous. The hours of teaching are increased and the work of preparation and maintenance of apparatus practically doubled. Fortunately, the subject has a strong hold on the interest of the boys and they work under the increased difficulties in a very commendable manner, and show a desire to be helpful that goes far in easing the work of the instructors.

The installation of a large motor-driven fan has solved the ventilation problem. We can now keep the air sufficiently pure that it is no longer a menace to health to spend two hours daily in the laboratory. On cold days we still freeze out unless we open the window leading to the space under Mr. Hawley's office and through this rob the furnace room of its hot air and the boiler of its draft. This difficulty should be overcome as soon as the extra radiators for heat and ventilation are installed that were ordered in August. Unfortunately, the company having the contract has been unable to secure any indirect radiators and can not proceed with the work which embraces the installation of an indirect radiator outside of and above each of four windows of the

laboratory. These will be boxed in so that air can be drawn through them and into the room while classes are in session. Provision is made that each radiator can be shut off not only to prevent freezing at night, but also to relieve the strain on the boiler while the building is being heated up in the morning.

The change in the course of study, particularly in Horticulture and all Engineering courses, has increased the need of more apparatus. Before this change most of the work was given to preparatory classes, little was offered above the freshman year. The laboratory was fitted for this grade of work, and much of the apparatus is not of the kind needed for college classes and can no longer be used. While this difficulty was foreseen and partially provided for, the funds available have not been sufficient for the needed equipment; through the desire also to help economize when the institution was curtailing expenses, the coming need has not been strongly emphasized. More equipment is imperative if College standards are to be maintained. To meet the necessity of training students for radically different lines of work, the equipment must necessarily be varied and extensive, and the purchasing of this should not be by single piece and spasmodically as heretofore, an expensive and uncertain method, but a certain known sum should be available each year for new equipment. Knowing that a fixed sum was available, the head of the department could plan his purchases systematically to best fit its needs, could take advantage of special bargains and get the more liberal discounts of large orders, particularly imported apparatus. I commend the needs of the department and this plan of apportioning funds to your consideration.

ELECTRICAL ENGINEERING.

The growth of the course in Electrical Engineering, and the interest and enthusiasm shown by the students, prove the wisdom of your action in reinstating the course in the curriculum of the College, and abundantly justify the expense that has been necessary so far. The records show an enrollment of ten juniors out of a total of twenty-four and of fourteen sophomores out of a total of thirty-three in all engineering courses. All but three sophomores of last year returned; one of these will enter school this winter term, and another is earning money to return next year. We are teaching in all two classes for a credit requirement of ten term hours and have a total enrollment of twenty-four. The Mechanical Laboratory has been partially fitted up for work in electrical measurements. The work of teaching is heavy; in part because all apparatus is kept in the Physical Laboratory and must be carried back and forth; in part on account of the unfinished condition of the installation. The students are making the best of the unfavorable conditions and are helping to whip things into shape.

The new equipment installed last summer is giving excellent service and is proving very well adapted for the purpose intended.

As much as possible of this work was done by student labor and furnished good experience. On account of an unforeseen delay in getting the last machine, the work is not completed and it has not been possible, as yet, to use electric power in the shops. There is therefore no basis for comparative cost of steam and electric power, but we are confident that the latter will prove enough cheaper to save the cost of its installation inside of five years. The cost of power for electrical measurements has not exceeded 60 cents per month so far.

The work of this course is so promising and its field of usefulness is so large that it deserves your earnest consideration. It has started out without a building and with meager equipment; the boys who are placing their faith and hope in the training it is to give are entitled to all the help you can bestow. If you consider the money spent per student in Physics and Electrical Engineering last year and keep in mind also the high cost of apparatus, I believe you will agree that our requests have been moderate and that we are entitled to a more liberal allowance. We are competing with schools where Electrical Engineering has been long established, where both laboratory and testing rooms are well equipped. To get our share of students, it will be necessary not only to put the work of instruction on a par with the best technical schools, but also to furnish the equipment that makes this possible. I believe you will agree with me that the money spent so far makes a creditable showing. At least double as much should be available for this year if full preparation is to be made for the entire work of the course next year.

Two of us, with the help of two student helpers and a student mechanician, are carrying all the work of teaching and general supervision. Mr. William E. Bracket, our able assistant, last year resigned in August to accept a call from the State University, and Mr. Fred G. Person, a graduate of Colorado University, and for three years principal of the Montrose County High School, took his place in the department. Mr. Person is proving himself a strong man in the work and is carrying his share of it in a very satisfactory manner.

The regular requirements of the curriculum will be so heavy another year that another teacher will be needed in the department; serving as it does each of the four years of College work in some of the several courses, the demands made upon it are severe. The training in Physics is fundamental and must be good. The work in Electrical Engineering must be high class if your plans for it are to come true. I trust you will consider this need of more instructors at your mid-winter meeting, so we can begin an early search for a strong, energetic, well-trained young man, preferably a graduate from one of the great technical schools of the East, for associate professor in Electrical Engineering next year.

Respectfully submitted,

CHARLES A. LORY,
Professor of Physics and Electrical Engineering.

SUPPLEMENTAL REPORT.

Department of Electrical Supplies.

The Department of Physics and Electrical Engineering, with the help of student labor, is taking care of all electrical work, new wiring and repair, on the Campus. Although the system has not been worked up to the efficiency we hope to get, in many respects it is far more satisfactory than the old method of contract service. Its most commendable feature is the chance it offers the Electrical Engineering students for practical experience. A better system of keeping check on the supply room is being worked out; the difficulties of this problem would be much less if we had better storage room. Our method of buying supplies also needs improvement. The cost on small orders of electrical supplies is high, practically no discount being offered. On large quantities the discount may reach 40 per cent. It should be possible for the College to make some arrangement with a local supply firm whereby we could get supplies in small quantities as needed, and yet, on account of the volume of business for the year be entitled to very nearly wholesale-order discount rates.

A number of much-needed repairs to our transmission lines were made last summer. All the power wires in the Mechanical Engineering Building were installed in iron conduits, and the distribution system as a whole was overhauled. Nearly all the buildings are still without main service switches and adequate fuse protection. These should be provided as soon as possible. I recommend for your consideration the installation of incandescent lights at the portals of all the buildings, especially those of the Main, Civil Engineering, Domestic Science and Chemical Buildings, and at the fountain for illuminating the Campus. This plan will be cheaper than the use of arc lamps, and will serve the purpose admirably. The lights would be turned out by the night watchman at any desired hour.

I recommend for your consideration also the installation of metallic filament lamps in all sockets not within easy reach of the students. Their use would increase our illumination and decrease the cost of energy. The use of clear lamps in the Chapel is very trying on the eyes, and spoils what otherwise is a very pleasant effect; frosted lamps only should be used in this room, and if Tungsten lamps were used the cost of energy per candle hour would show a decrease of fully 40 per cent., or a decrease of over 20 per cent. if Tantulum lamps were used. Our present method of exchanging lamps, i. e., free renewals with the power

station, is neither satisfactory nor advantageous. We are forced to use a 115-volt lamp on 104-volt circuits, which means poor illumination, and the low efficiency lamps furnished by the Company means high meter bills. Conditions are such that we will soon be forced to our former plan of buying our own lamps. The high cost of the new metallic filament lamps will prevent their use in sockets accessible to the students. We have had a great many lamps stolen this fall, many students apparently believing it legitimate to replenish their incandescent lamp stock at the College. The trouble has become so bad in some buildings that the use of a special lock socket is advisable. In sockets not easily accessible the new high efficiency lamp should be used, because, in spite of first cost the saving of energy their use makes possible will warrant their installation.

Respectfully submitted,

CHARLES A. LORY,
Professor of Physics and Electrical Engineering.

REPORT OF THE DEPARTMENT OF VETERINARY SCIENCE.

To the State Board of Agriculture:

Gentlemen—In my report of one year ago this prophetic statement was made: "In one particular this course of study (Veterinary) is to be looked upon as entirely different from others. In the ordinary vocations of life, a question is seldom asked as to a man's preparation for his work, whether within college walls or otherwise; it simply remains for him to prove what he can do. In the profession of medicine it is quite different, for here he is judged by his co-workers uncompromisingly according to the reputation of the school from which he received his degree.

"This department has now launched out as a full-fledged veterinary college, and we shall need to look to our educational standing that we may compare favorably with older schools. I fully appreciate the moral responsibility devolving upon us to see that our graduates are eligible to employment in the Bureau of Animal Industry and to membership in the American Association of Veterinarians.

"The American Association have their eyes upon us, and they carefully investigate every school seeking recognition, and have black-listed several. The graduates from such schools are without standing. They are not employed by the Department of Agriculture, neither are they granted certificates to practice in many of the states.

"To rank among the list of recognized veterinary colleges, we must have at least three veterinarians on the regular faculty who are eligible to membership in the American Association. The curriculum must be satisfactory and the subjects therein named must be actually taught with a degree of efficiency that will be beyond question. And lastly, the equipment must be ample, and a large clinic is indispensable."

Within a few months after this report was made, the Department of Agriculture appointed a committee of five to investigate the Veterinary Schools of America. The committee visited us unexpectedly, and before we had scarcely opened our doors five months as a full-fledged veterinary school. We were placed in Class C, which would make our graduates, if we had any, ineligible to the Civil Service Examination, and which in substance practically black-listed us among Veterinary Colleges.

The committee, after making their report, addressed the following letter, indicating where we had failed:

EXHIBIT "K."

"COPY OF REPORT ON THE VETERINARY DEPARTMENT COLORADO STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS, BY THE COMMITTEE ON VETERINARY EDUCATION."

"After having visited the Colorado State College of Agriculture and the Mechanic Arts, Department of Veterinary Science, on March 13, 1908, and obtained all available information, the following are submitted as the most important points at which that institution must be strengthened in order to come up to the minimum standard of requirements deemed essential by this committee:

"1. The faculty of this institution has on it an insufficient number of veterinarians teaching major subjects. At the time of our visit instruction was being given to only first and second year students. It is the opinion of the committee that the faculty as at present constituted lacks veterinarians who have had adequate training and experience in veterinary lines. There are at present only three veterinarians on the faculty giving sufficient time to college work, and two of these—I. E. Newsom and H. E. Kingman—have not had the necessary veterinary college training to render them eligible to membership in the American Medical Veterinary Association or to the civil service examination for employment in the United States Department of Agriculture."

"2. The buildings and equipment for offices, bacteriological laboratory, and class rooms are inadequate to the needs of the institution. It also appears that the material available for clinical instruction is insufficient."

Previous to the investigation made by the Department of Agriculture, we were trying to line up to the standard set by the American Veterinary Medical Association. We had three veterinarians on the teaching staff and otherwise were trying to come up to their standard. It could scarcely be expected that within a few months after opening our doors that we would be fully equipped and up to the standard of older schools.

The Department of Agriculture has now set a higher standard for us and which we are obliged to live up to or be discredited everywhere.

Their report, Recommendation No. 10, reads: "That there shall be at least five qualified veterinarians on the faculty of every veterinary college, each of whom shall have had not less than three years' experience in teaching or in practicing veterinary science subsequent to graduation from a veterinary college."

Recommendation No. 12: "That five veterinarians on the faculty of each veterinary college shall have charge of and teach the following major subjects: (1) Anatomy, (2) Pathology, (3) Practice of Comparative Medicine, (4) Surgery, and (5) Materia Medica, or Physiology, as the respective colleges may elect."

Recommendation No. 5 is a course of study given as a minimum for veterinary colleges, and also indicates how these subjects shall be taught and the minimum number of hours that shall be devoted to each subject.

As a whole the requirements are very exacting, but in no respect unreasonable, and are, we must admit, fully in accord with the up-to-date idea of veterinary education in America.

We have been bending every effort to meet these requirements before the termination of our period of probation, which is June 10, 1909.

Dr. I. E. Newsom and Dr. H. E. Kingman were perfectly competent and efficient in every way, but were caught by a technicality and they immediately resigned to continue their work in the Kansas City Veterinary College.

There is no change in our "buildings and equipments for offices." A temporary shift has been made to meet their criticism of our bacteriological laboratory by using a small room in the horticultural building. As to their criticism that our "class rooms are inadequate to the needs of the institution," I can only say that it is true. We have one new class room, but the largest one will scarcely hold the forty-five students registered for the work.

I trust that we may be permitted to ask the incoming Legislature for a special appropriation for at least one wing of a veterinary building. I feel sure that we will be able to meet every criticism this year, save the one respecting our buildings, class rooms and laboratories.

Their next criticism: "It also appears that the material available for clinical instruction is insufficient." This objection has been entirely overcome. We have exercised every effort to enlarge upon the practical work and have been rewarded with a clinic which will successfully refute any objections in this respect in the future.

OUR TEACHING STAFF.

Dr. B. F. Kaupp is a leader in the veterinary profession of America. He is the author of a standard text-book on parasites and a teacher and writer of national repute.

Dr. C. L. Barnes is a graduate of Cornell University, and is an experienced teacher and practitioner. He has been generous enough to place in the hospital for use, temporarily, several hundred dollars' worth of veterinary instruments.

Dr. Robert Bird, of Greeley, has kindly consented to come over twice a week and help us. He will help us, however, only

during the winter term of this year. At the beginning of the spring term we shall need to make some other arrangements.

Dr. F. W. Culver, of Longmont, comes up twice a week to lecture. These last two men are only temporary and will need to be replaced by permanent instructors to make the required five teaching major subjects.

Here is a matter that is causing me much concern; we are required to have five Veterinarians in charge of and teaching five major subjects, and two of these men, Drs. Bird and Culver can only help us until the spring term. There are no other local Veterinarians qualified to take up the work; besides, there would not be much difference in the expense of employing two men regularly, and several men from the outside who can only give us three or four hours a week, and are always more or less inefficient and at best uncertain.

Under the present regimen, the three classes in the regular Veterinary Course, the two in the practical Short Courses, and two in Farriery, require eighty-five hours per week of actual teaching, to be done by Dr. Kaupp, Dr. Barnes and myself. This amount of labor makes good work prohibitive if continued long, and portends an early departure to the world beyond. I am struggling with these difficult problems, trying to build up a department which will be a credit to the College and the State.

MICROSCOPES.

Twenty-five more microscopes are absolutely essential to the work in our several Veterinary Laboratories next year. By ordering these microscopes about March 1, from Germany, they could be gotten here by September and save us three hundred dollars.

TO SECURE RE-RATING.

Recommendation No. 17 reads as follows: "That these Colleges not now in Class A shall be put in that class at such time as they shall submit sufficient evidence to convince the Department of Agriculture that they are fully and faithfully complying with the minimum standard of requirements indicated in this report."

In compliance with this recommendation we have already forwarded to Washington a full and complete report of our work and now confidently await their will and pleasure.

PATHOLOGY MUSEUM.

We have already gotten together a Pathology Museum of which we are proud. It not only is an appropriate acquisition to a school of this kind, but greatly facilitates the teaching and represents an intrinsic value of possibly five hundred dollars.

VACCINE.

We have undertaken the manufacture of black leg vaccine, and, in conjunction with the Experiment Station, hog cholera serum. We now have the vaccine ready for distribution. Its manufacture involves much painstaking labor, but does not represent much money invested. We can make a vaccine in our laboratories which will be of superior quality, and sell it to the farmers and stockmen of Colorado at a price that will be a great saving to them and at the same time render a substantial support to the Veterinary Department, if you will authorize its being so used. He now have about two thousand dollars' worth ready for distribution.

HOSPITAL.

The practical work in Veterinary education is indispensable. At the hospital we have worked up a good clinic and done it in the only way that it could be done, by going out and working for it. We charge a reasonable fee for some of the cases treated and this goes a long way toward paying the expense of operating it.

PROSPECTUS.

While I am having my difficulties in getting this Department on a secure footing, yet I feel rewarded in the evidence of appreciation by all concerned and especially in the loyalty of the student body.

Last fall, while we were discredited as a Veterinary school and the institution in other respects was undergoing a turmoil, the young men that were with us the year before were loyal enough and had faith enough in us to come back and cast their lot with us. We now have forty-five registered, and next year, if we succeed in getting placed in Class A and are properly supported, we may confidently expect fully one hundred.

The Kansas City Veterinary College has over five hundred students registered in Veterinary Science and each one of them pays an annual tuition of one hundred dollars. Veterinary education is popular now, and we may expect to see this Department grow commensurate with the popular wave and with the support which it receives.

Respectfully submitted,

GEORGE H. GLOVER.

REPORT OF THE YOUNG MEN'S CHRISTIAN. ASSOCIATION.

To the State Board of Agriculture:

Gentlemen—This report includes the principal activities of the Association from the close of last school year to the present date.

SUMMER WORK.

Sixteen men attended the Student Conference which was held at Cascade, Colorado, from June 12th to 22d. This number included two faculty men and the retiring and present secretaries. The present secretary attended, also, the Student Secretaries' Conference at Geneva, Wisconsin, June 23d to July 6th.

NEW STUDENT WORK.

Letters of welcome and information, concerning both the Association and College, were sent to all prospective students. A complete list of the rooms and boarding places was secured and the greater part of both the old and new students were aided in getting located. During the opening day, the trains were met by men with badges from the Association and all newcomers were taken in charge and helped in every way possible.

SOCIAL DEPARTMENT.

The Association recognizes the need of a social life that will reach *all* the students, and they have carried out the following plans thus far:

The "Stag Social" (Sept. 11th) was held the first Friday night and almost every man in College attended. "Stunts" were so arranged that all had a full evening of fun.

The "Joint Reception" (Sept. 18th) was given in conjunction with the Young Women's Christian Association, and was attended by about two hundred people.

Bible-class parties have been held on different Friday evenings in the Rest room. Most of the men and women in the classes have been entertained in these small parties, and it shall be the aim of the Associations to provide social life for those who most need it throughout the year.

BIBLE STUDY.

Two courss are being offered this year by the Association in Bible study, "Men of the Old Testament" (Willman) and

"The Life of Christ" (Murrey). The student leaders are in a Normal Training Class led by the Secretary. Sixty-five men are now enrolled in these classes.

RELIGIOUS MEETINGS.

The plans of the Religious Meetings have been changed this year. The regular Sunday meeting has been held as usual, but due to the chapel hour being abolished, the mid-week meeting is held with the Young Women's Christian Association each Tuesday evening at 6:45 for three-quarters of an hour. The mid-week meeting is strictly a student meeting, while the Sunday meetings are addressed by the ministers and men from the outside.

Some special meetings have been held, two of which I shall especially mention. Dr. Winfield S. Hall, dean of Northwestern University, addressed 350 men with his noted lecture on "Reproduction and Sexual Hygiene," and "Dad" Elliott, an international traveling secretary, held a three days' campaign here the first of November.

EMPLOYMENT.

Some men have been placed in permanent positions and a large number have been given odd jobs to do. The first month of school there was about $50.00 worth of work obtained for the students through the Association employment bureau.

PRACTICAL COURSE STUDENTS.

Letters were sent to all the Practical Course Students, and they were cared for the same as the Regular Students when they came. They were aided in securing room and board, a place to get their washing done and all the necessities that were required; in addition they were given special attention and advice as to the different activities of college life.

FINANCES.

The income thus far this year has been $388.00. This includes the balance on hand, subscriptions paid, convention funds repaid, mission pledges and some small items. The expenditure has been $195.81, leaving a balance on hand of $192.19.

It is estimated, by careful figuring, that we shall have to raise at least $175.00 more than has been pledged to meet the current expenses this year.

ADMINISTRATION.

The Association office has been supplied with good magazines and literature and it is open most of the time for the stu-

dents to read and study in. A number of the students are making use of it.

The vacancies in the Cabinet have been filled and the machinery of the Association is now working very well.

The Secretary wishes to express his appreciation of the hearty co-operation of the State Board in so materially aiding the Association in making it possible for this work to be carried on.

Respectfully submitted,

WARD E. HALL,
General Secretary.

November 15, 1908.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY.

To the State Board of Agriculture.

Gentlemen—I have the honor to present the following report from the Department of Zoology and Entomology for the year just closing.

The personnel of the department has not changed during the past year.

Professor S. Arthur Johnson is associate professor in the Department. Mr. L. C. Bragg looks after the College Museum and gives considerable of his time to the Entomological work of the Department. Miss Palmer does most of her work for the Experiment Station and also does some teaching and some breeding cage work and keeping of records.

On account of my devoting more time to research and other Experiment Station work I find it necessary to turn the teaching over quite largely to Professor Johnson, who has proven himself very successful as an instructor of college students.

During the past year I have attended six Short Courses of one week each, and a considerable number of farmers' meetings of one day each, and given addresses, chiefly along the line of economic entomology.

The utmost harmony has prevailed in the work of the Department throughout the year.

There have been a few donations to the College Museum during the year, but on account of the lack of money to make any purchases either of speciments or needed cases, the museum is practically in the same condition that it was one year ago.

Appended hereto is an invoice of College property cared for in this Department.

Respectfully submitted,

C. P. GILLETTE.

Fort Collins, Colo., October 30, 1908.

AUDIT OF

State Agricultural College

FROM

DECEMBER 1, 1906, TO NOVEMBER 30, 1907

AND

DECEMBER 1, 1907, TO NOVEMBER 30, 1908

Hon. B. F. Rockafellow,

President State Board of Agriculture,

Fort Collins, Colorado.

Dear Sir—Pursuant to the instructions of your Executive Committee, we have made an audit of the books and accounts of the State Agricultural College, from December 1, 1906, to November 30, 1907, inclusive, and herewith submit our findings:

SECRETARY'S CASH.

All collections have been properly accounted for and paid over to the State and College Treasurers.

DISBURSEMENTS.

All disbursements are evidenced by duly authenticated bills, and all vouchers are properly approved by the Finance Committee.

COLLEGE TREASURER.

We verified the balances shown as in the hands of the College Treasurer as of date November 27, before issuance of November warrants, at which time the balance, per books, was—

		$29,918.56
Warrants outstanding		
Tax Fund, No. 154	11.15	
Tax Fund, No. 921	50.00	
Tax Fund, No. 1012	89.09	
Experiment Station Appropriation, No. 1	62.50	
Experiment Station Appropriation, No. 18	6.52	
Bank balance		$30,137.82

STATEMENTS.

The following statements exhibit the transactions of the past year:

SECRETARY'S CASH ACCOUNT.

RECEIPTS.

Secretary's Office, Sales	$ 1.50	
Agronomy Division, Sales	20.00	
Animal Husbandry Division, Sales	7,422.27	
Farm Division, Sales	77.30	
Farm Mechanics Division, Sales	33.90	
Botany and Horticultural Division, Sales	127.95	
Chemical Division, Sales	100.00	
Domestic Science Department, Sales	24.86	
Library	32.80	
Insurance, Return Premium	5.40	
Transfers, College Funds	9,285.73	
Text Book Department, Sales	2,795.03	
Entrance Fees	330.00	
Commercial Department	60.00	
Agronomy Section	183.71	
Animal Investigation Section	1,568.87	
Veterinary Section	45.85	
Western Slope Fruit Investigation	375.00	
Transfers, Experiment Station	5,038.52	
Government Horse Breeding	170.00	
Delta County Fruit Investigation	700.00	
Horticultural Section	76.13	
COLLEGE SPECIAL FUND—		
Paid State Treasurer		$ 2,655.14
Paid College Treasurer		16,564.88
EXPERIMENT STATION, SPECIAL FUND—		
Paid College Treasurer		9,202.30
HATCH FUND—		
Paid College Treasurer		52.50
	$28,474.82	$28,474.82

RECEIPTS AND DISBURSEMENTS.

	Balance Dec. 1, 1906.	Receipts	Transfers to	Transfers from	Disbursements	Balance State Treasury	Balance College Treasury
Agricultural College							
Tax Fund	$ 1,994.55	$ 69,780.05	$ 7,400.00	$ 2,366.56	$ 89,130.22	$ 221.07	$16,532.35
Land Income Fund	358.05	8,188.04	.....	.....	5,422.66	963.96	2,159.47
Special Fund	3,210.80	9,934.29	9,285.73	.....	15,690.25	.....	5,240.57
*Secretary's Revolving Fund	.....	.....	.....	.....	.....	.....	1,500.00
Mechanical Arts (U. S.)	8,854.56	30,000.00	.....	.....	24,100.17	.....	14,754.39
Purchase Fund	.....	13,585.25	.....	7,400.00	6,185.25	.....	.....
Appropriation, Farmers' Institute	.....	10,000.00	.....	2,724.83	712.36	5,000.00	1,562.81
Appropriation, Land and Water	.....	7,500.00	.....	.....	7,500.00	3,750.00	3,750.00
Appropriation, Irrigation Building	.....	16,633.84	.....	4,194.34	.....	.....	12,439.50
Experiment Station—							
Hatch Fund	286.47	15,000.00	52.50	.....	12,785.00	.....	1,981.03
Adams Fund	455.26	5,250.00	.....	.....	8,605.81	.....	2,900.55
Special Fund	1,065.84	4,216.28	4,986.02	52.50	9,147.33	.....	1,068.31
Appropriation, Animal Investigation	.....	6,000.00	.....	545.21	1,996.36	3,000.00	458.43
Appropriation, Plant Industry	.....	4,000.00	.....	1,292.03	339.90	2,000.00	368.07
Appropriation, Grain House	.....	2,000.00	.....	.....	.....	1,000.00	1,000.00
Appropriation, Farm Mechanics	.....	2,000.00	.....	.....	.....	1,000.00	1,000.00

Appropriation, Veterinary	.....	500.00	.....	172.54	67.50	250.00	9.96
Appropriation, Fruit Investigation	.....	8,000.00	.....	2,969.74	423.12	4,000.00	607.14
Appropriation, Horse Investigation	.....	5,000.00	.....	6.50	473.23	2,500.00	2,020.27
		$11,663.49	$217,587.75	$21,724.25	$21,724.25	$182,579.16	$23,685.03	$22,987.05

*In Secretary's hands.

DISBURSEMENTS, COLLEGE FUNDS.

Agricultural Department—	
General Division	$ 2,855.26
Agronomy	1,156.94
Animal Husbandry	7,933.17
Farm	7,537.65
Farmers' Institute	5,316.04
Farm Mechanics	619.55
Advertising	2,820.39
Botany and Horticultural Department	1,790.29
Bookkeeping and Farm Accounts	34.58
Chemical Department	181.88
Civil and Irrigation Engineering	1,093.28
Constitutional History and Irrigation Law	2.75
College Campus	2,308.64
Current Expense	2,389.28
Domestic Science	931.24
Firemen and Janitors	4,161.78
Fuel and Lights	4,626.42
Furniture and Fixtures	849.43
Girls' Dormitory	731.00
General Repairs	1,262.34
History and Literature	36.87
Insurance	1,389.75
Library	2,081.57
Mathematical Department	44.85
Mechanical Department	1,661.71
Military	478.14
Music Department	75.83
President's Office	854.70
Physical Training Department	8.35
Physics Department	996.88
Permanent Improvements	18,223.37
Quarterly Bulletins and Reports	1,335.76
Rhetoric and Composition	58.20
Salary	65,993.93
Secretary's Office	673.87
State Board of Agriculture	1,358.20

DISBURSEMENTS, COLLEGE FUNDS—Concluded.

Student Labor	3,421.19	
Text-book Department	389.99	
Veterinary Science Department	511.22	
Zoology and Entomological Department	544.62	
Total		$148,740.91

DISBURSEMENTS, EXPERIMENT STATION.

Agricultural Section	$ 69.55	
Agronomy	1,753.41	
Animal Investigation	6,394.64	
Arkansas Valley Field Agent	63.56	
Bulletins and Report	2,004.22	
Chemical Section	598.38	
Director and General	1,054.68	
Delta County Fruit Investigation	387.46	
Entomological Section	645.47	
Fruit Investigation	423.12	
Horticultural Section	809.65	
Horse Investigation	473.23	
Irrigation Section	765.34	
Library	671.59	
Plant Industry	339.90	
Salary	15,186.16	
Veterinary Section	285.89	
Western Slope Fruit Investigation	1,912.00	
Total		$33,838.25

GENERAL COMMENTS

BOOKS AND RECORDS.

Our recommendations of last year have been carried out, and the books consolidated into two Voucher Records, one Journal, and one Ledger.

DISTRIBUTION

Has been made in accordance with our former recommendations.

CASH DISBURSEMENTS.

The Secretary has now been provided with a Revolving Fund to be used in making petty cash payments, as recommended.

OFFICE METHODS

Have been much improved and the labor decreased, by drawing all funds from the State Treasurer in bulk and making disbursements through the College Treasurer only; thus avoiding the unnecessary duplication of vouchers.

BILLS AND REQUISITIONS.

The practice still obtains, in many instances, of purchasing goods first and obtaining requisition later.

STUDENT LABOR.

We renew our recommendation that these items be paid on a regular form of Pay Roll, by the Secretary, one voucher to be made monthly for the total.

CERTIFICATE.

We have made an audit of the books of The State Agricultural College, from December 1, 1906, to November 30, 1907, inclusive; and in accordance therewith we certify that the foregoing statements correctly represent the transactions for the period named.

THE CONTINENTAL AUDIT COMPANY,

(SEAL) [redacted],

L. F. ARTHUR, Secretary.

Dated December 4, 1907.

AUDIT STATE AGRICULTURAL COLLEGE.

December 1, 1907, to November 30, 1908.

HON. B. F. ROCKAFELLOW,

President State Board of Agriculture,

Fort Collins, Colorado:

Dear Sir—Pursuant to the instructions of your Executive Committee, we have made an audit of the books and accounts of the State Agricultural College from December 1, 1907, to November 30, 1908, inclusive, and herewith submit our findings.

SECRETARY'S CASH.

All collections have been properly accounted for and paid over to the College Treasurer.

DISBURSEMENTS.

All disbursements are evidenced by duly authenticated bills, and all vouchers are properly approved by the Finance Committee.

COLLEGE TREASURER.

We verified the balances shown as in the hands of the college treasurer, as of date November 30, 1908, at which time the balance, per books, was $37,133.66

Warrants outstanding—

Tax fund	No. 2505	80.00
Tax fund	No. 2570	2.00
College special	No. 265	75.00
Experiment station appropriation.....	No. 293	14.00
Bank balance		$37,304.66

STATEMENTS.

The following statements exhibit the transactions of the past year:

SECRETARY'S CASH ACCOUNT.

RECEIPTS.

Agronomy Division	$ 10.23	
Animal Husbandry	4,527.27	
Farm Division	438.12	
Farm Mechanics	9.25	
General Agriculture	67.15	
Farmers' Institute	2,424.00	
Botany and Horticultural Department	53.70	
Chemical Department	238.54	
Civil and Irrigation Engineering	393.35	
Domestic Science	26.38	
Library	49.73	
Mechanical Department	38.25	
Military Department	3.00	
Physics	86.34	
Veterinary	59.59	
College Campus	3.55	
Girls' Dormitory	64.54	
Text-book Department	83.40	
Entrance Fees	569.70	
Miscellaneous Sales	34.00	
Agronomy Division	491.39	
Animal Investigation Division	7,021.13	
Chemical Section	9.20	
Horticultural Section	121.69	
Fruit Investigation	35.00	
Plant Industry	28.30	
Horse Investigation	524.20	
Delta County Fruit Investigation	100.00	
Government Horse Breeding	5.00	
Transfer from Appropriation	6,710.62	

DISBURSEMENTS.

College Special Fund—		
Paid College Treasurer		$ 9,180.09
Experimental Special Fund—		
Paid College Treasurer		15,046.53
	$24,226.62	$24,226.62

RECEIPTS AND DISBURSEMENTS.

	Balance Dec. 1, 1907						Balance Nov. 30, 1908	
	State Treasurer	College Treasurer	Receipts	Transfers To	Transfers From	Disbursements	State Treasurer	College Treasurer
Agricultural College—								
Tax Fund	$ 221.07	$16,532.35	$ 72,578.34	.....	.....	$ 80,522.31	$ 1,299.41	$25,554.66
Land Income Fund	963.96	2,159.47	11,497.40	.....	.....	14,116.26	461.36	43.21
Special Fund	.....	5,240.57	9,180.09	.....	.....	14,319.34	.....	101.32
*Secretary's Revolving Fund	.....	1,500.00	.....	.....	.....	.....	.....	1,500.00
Mechanical Arts (U. S.)	.....	14,754.39	35,000.00	.....	.....	29,349.90	.....	20,404.49
Appropriation, Farmers' Institute	5,000.00	1,562.81	.....	.....	.....	6,562.81	.....	.....
Appropriation, Land and Water	3,750.00	3,750.00	.....	.....	.....	.....	.....	.....
Appropriation, Irrigation Building	.....	12,439.50	.....	.....	.....	12,439.50	.....	.....
Experiment Station—								
Hatch Fund	.....	1,981.03	15,000.00	.....	.....	15,005.49	.....	1,975.54
Adams Fund	.....	2,900.55	14,256.22	.....	.....	9,956.83	.....	1,399.84
Special Fund	.....	1,068.31	8,335.91	$ 6,710.62	.....	5,219.82	.....	10,895.02
Appropriation, Animal Investigation	3,000.00	458.43	.....	.....	$ 1,816.74	1,641.69	.....	.....
Appropriation, Plant Industry	2,000.00	368.07	.....	.....	739.72	1,628.35	.....	.....
Appropriation, Grain House	1,000.00	1,000.00	.....	.....	.....	2,000.00	.....	.....
Appropriation, Farm Mechanics	1,000.00	1,000.00	.....	.....	643.19	1,356.81	.....	.....
Appropriation, Veterinary	250.00	9.96	.....	.....	113.98	145.98	.....	.....

RECEIPTS AND DISBURSEMENTS—Concluded.

	Balance Dec. 1, 1907						Balance Nov. 30, 1908	
	State Treasurer	College Treasurer	Receipts	Transfers To	Transfers From	Disbursements	State Treasurer	College Treasurer
Appropriation, Fruit Investigation	4,000.00	607.14	.....	.....	1,574.12	3,033.02	.....	.....
Appropriation, Horse Investigation	2,500.00	2,020.27	.....	.....	1,822.87	2,697.40	.....	.....
Totals	$23,685.03	$22,987.05	$165,847.96	$ 6,710.62	$ 6,710.62	$199,994.51	$ 1,760.77	$10,764.76

*In Secretary's hands.

DISBURSEMENTS, COLLEGE FUNDS.

Agricultural Department—	
General Division	$ 1,877.97
Agronomy	979.15
Animal Husbandry	7,725.58
Farm	8,901.09
Farmers' Institute	8,246.63
Farm Mechanics	361.92
Advertising	3,062.46
Botany and Horticultural Department	2,415.66
Chemical Department	458.57
Civil and Irrigation Engineering	790.83
Constitutional History and Irrigation Law	69.60
College Campus	1,368.06
Current Expense	2,434.96
Domestic Science	753.63
Firemen and Janitors	4,227.32
Fuel and Lights	4,398.07
Furniture and Fixtures	797.83
Girls' Dormitory	366.00
General Repairs	2,762.68
History and Literature	26.57
Insurance	315.00
Irrigation Building	12,439.50
Library	1,452.50
Mathematical Department	13.37
Mechanical Department	1,189.55
Military	186.68
Music Department	219.13
President's Office	677.78
Physical Training Department	28.35
Physics Department	1,256.77
Permanent Improvements	2,016.35
Quarterly Bulletins and Reports	1,347.80
Rhetoric and Composition	45.47
Salary	75,526.20
Secretary's Office	458.57
State Board of Agriculture	1,578.23
Student Labor	4,027.46

DISBURSEMENTS, COLLEGE FUNDS—Concluded.

Text Book Department	250.00	
Veterinary Science Department	967.60	
Water Assessments	1,198.44	
Zoology and Entomological Department	90.79	
		$157,310 12

DISBURSEMENTS, EXPERIMENT STATION.

Agronomy	$ 668.74	
Animal Investigation	3,725.93	
Arkansas Valley Field Agent	184.19	
Bulletins and Reports	3,290.41	
Buildings	450.00	
Chemical Section	799.82	
Director and General	977.71	
Delta County Fruit Investigation	417.57	
Entomological Section	683.32	
Farm Mechanics	1,375.72	
Fruit Investigation	3,354.28	
Grain House	2,000.00	
Horticultural Section	2,730.11	
Horse Investigation	3,004.28	
Irrigation Section	915.37	
Library	123.20	
Plant Industry	1,722.48	
Salary	16,034.88	
Veterinary Section	226.38	
		$ 42,684.39

CERTIFICATE.

We have made an audit of the books of the State Agricultural College, from December 1, 1907, to November 30, 1908, inclusive; and in accordance therewith, we certify that the foregoing statements correctly represent the transactions for the period named.

THE CONTINENTAL AUDIT COMPANY,
E. F. ARTHUR,
(SEAL.) [redacted], Secretary.
Dated December 7, 1908.

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

TWENTY-FIRST ANNUAL REPORT

OF

THE AGRICULTURAL EXPERIMENT STATION

FOR

1908

THE AGRICULTURAL EXPERIMENT STATION.

FORT COLLINS, COLORADO.

THE STATE BOARD OF AGRICULTURE.

	Term Expires.
HON. J. L. CHATFIELD, Gypsum	1909
HON. B. U. DYE, Rocky Ford	1909
HON. B. F. ROCKAFELLOW, *President,* Canon City	1911
HON. E. H. GRUBB, Carbondale	1911
HON. R. W. CORWIN, Pueblo	1913
HON. A. A. EDWARDS, Fort Collins	1913
HON. F. E. BROOKS, Colorado Springs	1915
HON. J. L. BRUSH, Greeley	1915

GOVERNOR HENRY A. BUCHTEL
PRESIDENT BARTON O. AYLESWORTH } *ex-officio.*

A. M. HAWLEY, *Secretary.* CHARLES SHELDON, *Treasurer.*

EXECUTIVE COMMITTEE IN CHARGE.

B. F. ROCKAFELLOW, *Chairman.* A. A. EDWARDS.
B. U. DYE.

STATION STAFF.

L. G. CARPENTER, M. S., *Director*.....Irrigation Engineer
C. P. GILLETTE, M. S.....Entomologist
W. P. HEADDEN, A. M., PH. D.....Chemist
WENDELL PADDOCK, M. S.....Horticulturist
W. L. CARLYLE, M. S.*.....Agriculturist
G. H. GLOVER, M. S., D. V. M.....Veterinarian
————†.....Agriculturist
W. H. OLIN, M. S.*.....Agronomist
W. G. SACKETT, B. S.**.....Bacteriologist
R. E. TRIMBLE, B. S.....Assistant Irrigation Engineer
F. C. ALFORD, M. S.....Assistant Chemist
EARL DOUGLASS, M. S.....Assistant Chemist
S. ARTHUR JOHNSON, M. S.....Assistant Entomologist
B. O. LONGYEAR, B. S.....Assistant Horticulturist
E. B. HOUSE, M. S.....Assistant Irrigation Engineer
F. KNORR, B. S.....Assistant Agronomist
P. K. BLINN, B. S....Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S.....Potato Investigations
MIRIAM A. PALMER.....Artist
L. C. BRAGG.....Assistant in Entomology

STATE FRUIT INVESTIGATIONS.

O. B. WHIPPLE, B. S., Grand Junction....Field Horticulturist
GEORGE P. WELDON, B. S., Delta***....Field Entomologist

President, BARTON O. AYLESWORTH, A. M., LL.D.

L. G. CARPENTER, M. S.....Director
A. M. HAWLEY.....Secretary
MARGARET MURRAY.....Clerk

*To October 19, 1908.
**From May 1, 1908.
†To be filled.
***From March 1, 1908.

LETTER OF TRANSMITTAL.

To His Exellency, Henry A. Buchtel, Governor of Colorado:

In accordance with the conditions of the act of Congress which requires a full and detailed report of the operations of the Experiment Station, I have the honor to present herewith the twenty-first annual report.

The financial statement is for the fiscal year ending June 30, the other portions being reported substantially for the current year.

The publication of the investigations is made in separate form as bulletins, and these are freely distributed among the people of the State.

L. G. CARPENTER,
Director.

The Agricultural Experiment Station, State Agricultural College, Fort Collins, Colorado, December, 1908.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit my report for the past year as Director of the Experiment Station, with accompanying reports of the various sections.

As usual, believing that the purpose will be best served, I have had prepared two reports by each, a brief one for your special information, and a longer one for publication. The reason for this is that you need to have information to act intelligently on questions. The steps are not of public interest and need not be published. The public not being in touch with the detail, needs much fuller statements in order that they shall understand the situation. I have asked each member of the station staff to prepare a brief report and a long report with these two purposes in view, and to some extent the purpose has been reached in covering these two objects.

In this report to you the principal thing besides calling attention to some features of the work will be to call attention to the line of development and the changes that are coming in station outlook, largely as a consequence of the Adams fund, and the new relations which it introduces.

The work in the office of the Director has very much increased. While ten years ago the available funds outside of the fixed charges were very small, they have very much increased. The fixed charges, like salaries, etc., cause no particular question to to arise in the office administration. The other, or unassigned sums, introduce a great many questions, and thus, the calls from this source are ten or twenty times as much as they then were. The office work has thus correspondingly increased. The increase in the number of funds has made considerable bookkeeping necessary in the Director's office. It has been necessary to keep an account with each fund in order to foresee the needs and to prevent some of the funds running short. The mailing of the bulletins alone is a serious task. There are now over 16,000 names on the mailing list. An edition of an ordinary 32-page bulletin weighs nearly a ton. The correspondence and routine work have also very largely increased. With the increase in the number of bulletins, a larger amount of space and more system has had to be used in keeping our files. The number of engravings in our different bulletins has so increased that it has become necessary to make special provision for indexing and cataloging the cuts. The increase in the revenue also has introduced a large number of experimental projects and it has become necessary to keep closer account with each of these projects. The increasing value of the stations throughout the United States brings a large variety of correspondence on incidental

questions. The result of all of these is to throw a large additional amount of work into the Director's office, and also upon all of the members of the station staff.

The office work has required three stenographers and clerks and was so divided as to give routine work to each, all under the charge of Miss Murray. Since the first of August we have been short one office helper. The consequence is that some of the routine work which could be postponed has been set aside, but much of this that has been postponed would be better to be kept up. It has thrown a good deal of routine work, especially the dictation, upon Miss Murray, in addition to the many other responsibilities.

Through the activity of Prof. Cottrell in farmers' institutes last year, the names on our mailing list have very materially increased, so that now we have more than 16,000 names on the list. Ten bulletins were issued during the year, amounting to 194 pages, or a total of 2,310,000 printed pages. The bulletins envelopes to mail a single edition cost $50. To lessen this expense, as well as to lessen the labor of mailing, several bulletins are mailed together.

The matter of bulletins brings up a number of serious questions. One is of ways and means, and the other is the scope of the bulletins which we should print. The pressing demand for information, and the attempt of the stations to meet the demand—because there has been no other source—has led to the issuance of many popular bulletins. These have not been scientific in character and consist sometimes largely of compiled information. These have been published in the name of the stations so as to have the advantage of the franking privileges, though the expense of the compilation has been borne by other funds. This has been especially true of Cornell, and this practice has led to misapprehension in other states concerning the scope of the stations where other funds have not been available. There is much doubt whether the Hatch fund should be chargeable with the expense of such bulletins, and I presume, with the development of the stations, which seems to be coming, that objection will be made by the government to such use of the Hatch fund.

The increase in the number of names and the general demand for popular bulletins makes a very large expense. Our printing bill for the fiscal year amounted to $3,000. No way has yet been found to distribute these publications so that many copies will not be wasted. In many states the station funds do not have to stand this expense, as the state prints the bulletins from other funds, and thus the activity of the stations, which results in more bulletins, does not have the effect of cutting down the funds available for work.

Bulletins which come as the result of scientific investigation are, with few exceptions, scientific in character, and usually can

not be expected to be popular, and will have a limited use. It has not, so far, seemed to be practicable to classify the names on the station list according to the subject that they are interested in, and, in fact, I doubt if this is advisable. The Geneva station, of New York, long ago adopted the practice of issuing two sets of bulletins—a popular edition, giving the main contents of the bulletins, but free from all technicalities, and from two to four pages in length. This means editorial supervision, and of a kind which the scientific author is not prepared to give. In that case the longer bulletin is mailed only on request. It has been found, however, that the shorter bulletins answered the purpose of most people. With the increase in our mailing list, and the probable larger number of bulletins, the expense of printing will be an increasingly serious one, and it may be necessary to adopt the Geneva plan or else to lessen the bulletins, which does not seem desirable.

In considering any new line of work and obtaining an appropriation from the State, I consider it very desirable that the sum appropriated should be large enough to cover any printing that would be required and the publication of bulletins. The propriety of using the Hatch fund to pay for printing of inquiries, which are not chargeable to the Government funds, is very doubtful, and if the propriety were not doubtful the expediency is, for, with the increase in the number of investigations which cluster about the Experiment Station, it would soon result that the Hatch fund would become nothing but a printing fund.

Last year a more systematic classification of the projects of investigation was undertaken, and blanks prepared, whereon each investigator outlined the projects which he wished to investigate, and gave definite details. The necessity for this had been increasingly evident, and the definite purpose was twofold. One, to cause each one to make a more definite plan than it had been customary; to consider in advance the definite object to be accomplished, definite methods for that purpose, and an estimate of the cost in time and in money. The second definite purpose was to cause each one to bring before himself a clear idea of the demands in time which his projects would require, and thus to cause him to reduce the number of attempted investigations. The number of questions in this State is so great that the temptation has been to undertake too many. In one case an investigator found that his projects, which he expected to complete in a year, would require nearly three years of his own time and nearly as much of an assistant.

In this, as in previous years, the Director has not attempted to interfere with plans and projects, but to guide and assist, and to cause a clear view of the element cost and time; to know in advance what to expect, and to prevent the entering upon projects which it would be impracticable to thoroughly carry out. I will not need to speak to any extent of the work in detail.

Notwithstanding these improvements in conditions, the same general fact has existed that nearly everyone has been tempted to undertake more than he could carry through. This has been partly due to an overestimate of the time available and an underestimate of the time and work required. The time required by the interference of other duties has almost always been underestimated. Other matters have this year prevented the scientific force from being able to work under the most effective conditions. Activities, as shown by the bulletins, have been maintained, but the scientific activity, which requires rather peculiar conditions, has certainly not been increased.

Some questions relating to this I will speak of more particularly in speaking of the development of the Station.

The revenue of the Station has been as follows:

From the U. S. Government, Hatch Fund	$15,000.00
From the U. S. Government, Adams Fund	8,756.22
From State Appropriations	27,500.00
From Other Sources	9,164.85
Total	$60,421.07

The conditions attached to the governmental funds—of both the Hatch and Adams—are such that they must be completely expended within the fiscal year ending June 30. In case there is any balance it is confiscated. In case there are any bills outstanding they can not be paid. This is true of each fund separately, so that it requires very careful prevision in order to bring them out exactly. The fact that the Adams fund is not even $9,000 for the last fiscal year is because the Department of Agriculture ruled that certain bills could not be paid from the Adams fund. Their previous practice had given reason to think that were proper. These were bill for books, such as Bailey's Cyclopedia of Agriculture, which were too general to be considered as required by specific scientific researches.

The State fund is the appropriation for two years. The Adams fund has special requirements, and, as previously indicated to you, has not had the effect of relieving our finances, but has required other expenditure, in order to take full advantage.

The State fund was that appropriated by the last Legislature, and includes the appropriations for special purposes. The appropriation of the Hatch fund is for

> "the purpose of paying the necessary expenses of conducting investigations and experiments, and for printing and distributing the results."

The Adams fund is

"for paying the necessary expenses of conducting original scientific research, etc."

The scientific investigations provided for by both appropriations need to be supplemented by additional funds. That is, while the experiments of an investigator leading, for example, to the production of a rust-resistant cantaloupe or the production of an improved variety of wheat, may be right and proper under the Hatch fund, the growth of that seed for distribution and its distribution is held as not being an expenditure that would be proper by the Government funds. Likewise, for example, the investigations that have led to the production of black-leg vaccine or serum for hog cholera, may be proper charges on the Government funds, yet, when it comes to the application of these to stock for commercial purposes, it passes the domain considered experimental, to the economic field. This can not be done by the Experiment Station under the Government appropriation, but might be done if other funds are provided. Now it is unnecessary to say that this part of the work is of great importance and needs to be provided for. It brings the work of the Station into actual contact with the economic needs of the farmer, and is a work which is immediately appreciated. It is for such purposes that appropriations from the State or other sources are actually needed. The State appropriations can be given under broad enough conditions, both to expand the work of the Experiment Station and to do this important work, which the Government funds can not be used for, even if they were large enough.

I attach a memorandum of the appropriations as passed by the last Legislature, and suggest that some action be taken to decide on what is desirable for the coming biennial period. The embarrassment which has been caused in the past because the State appropriations were not available until late in the fall is known to you. Our financial situation with regard to these funds is better now than it was two years ago. Having a local treasurer, it is possible to carry some of these funds, so that the balance in each, unless it be the Plant Industry and Animal Industry, will tide us over until the close of the Legislature.

In asking for additional appropriations, I would suggest that the appropriation in each line should be sufficient to pay all expenses, both direct and indirect, caused by the additional work. Thus the Fruit Investigation will illustrate. In this case the appropriation pays not only the traveling, office and other expenses, but also the salaries of the two men who are employed. It is also desirable to pay the expense of printing that is called for by it. The only expense thrown upon the Station and College is, therefore, the time required by the Horticulturist and the Entomologist, and of office work and some minor printing, etc., in all a very small amount.

The arrangement has been different with, for instance, the Plant Industry, where no salaries have been charged to this fund, except the wages of the laborers employed from time to time. In this case, therefore, the aid from the State causes the College to spend a large additional amount of money, and the same thing has been true of some of the other appropriations. I would therefore recommend that the amount asked for for Plant Industry, Animal Industry, etc., should be large enough to pay a proportional amount of the salaries of the men called for. Thus, for instance, the potato investigations for the past two years have been maintained by the College, and a small portion from the Experiment Station. This ought to be provided for by the legislature.

The memorandum is made as a suggestion. An explanation of the memorandum is attached to it.

It is proper to undertake some additional lines of work. Considerable call has been made at times for so-called experimental farms in different parts of the State. There is some good in these if too much is not expected. The community is apt to consider them as model farms, which is different even from demonstration farms or experimental farms. If a demonstration farm, the principal purpose would be teaching—that is, to show the application of principles already well known. A great difficulty is to get capable men. If a sub-station is established the community is apt to consider it as a model farm, and the superintendent is thus judged by the community by the way in which he maintains the place. Each one also expects a specialist who knows more about each crop than the most skilled man in the community. It is impossible for one man to meet all these standards, and especially for the sum of $800 to $1,200 per year, which is usually the amount available. There is, however, a field for demonstration farms or for test farms, in different parts of the State. It is objectionable and misleading to call them experimental farms. They are, however, expensive, and the same amount of money can do much more good in some other ways. The number of people who visit one of these places is small, so that as an educational influence its field is very limited. Calls have been made for such on the Plains. It is found that only a few visit these places, and the advantage, judging from past experience, would not be any better over many selected farms. Eastern Colorado is so big that the same amount of money could reach many more people by collection and distribution of information over that extensive area. Desires have been expressed for some such station in northwestern Colorado.

If it be thought best to undertake anything of this kind the assured income should be not less than $3,000 for each one per year. It would probably be better and more economical to arrange with some farmer in these localities and possibly make a

contract with him so that he will carry out instructions and raise crops as directed under approved methods, and in that case the cost might be brought down. The difficulty then would be for our present force to find time to give the necessary attention. One man might take up this special line of work and enough test farms of this kind be taken in different parts of the State to give him a reasonable amount of employment. In that case the assured income ought to be not less than $1,000 per annum for each. Such a method might avoid the necessity of buying farm machinery, teams and other equipment, which runs very quickly into money, and means a continuing expense to maintain.

The problem of the Plains has been brought up at various times. Some desire has been expressed for a substation there. The present condition calls for distribution of information rather than for additional substations. Their need is immediate. If there were the funds available a series of special institutes or meetings might be of very great value on the Plains, so as to meet the problems to some extent that are confronting the people there. The indications are that many have already moved out and that many more will move out before spring, or be pushed by dire necessity.

HORSE BREEDING WORK.

No report is available concerning the conditions of this investigation. The peculiar form of agreement with the U. S. Department of Agriculture has left the duties of the Director in somewhat ambiguous state, and the Director's office is possessed of little information. There have therefore been no reports in times past concerning the progress of the work, except a very short statement in the annual report. I learned sometime since that the Committee on Purchasing had recommended that a number of these colts be sold, and I obtained a copy of the report by applying to the Department of Agriculture at Washington. The opinion of all concerned is that the quicker these are sold the better, as it would relieve the investigation of the care and maintenance of these animals. The money derived from the sale of these colts would be returned to the Station or College as a portion of the cost. As the matter is somewhat in doubt, I bring it to you for action to order the sale of these animals, or to authorize the Director to take action. The sale might be either by public auction or a private sale. In the latter case a minimum price might be fixed. A third method has been suggested and that is to send these animals to Chicago or Omaha, so that their identity might be lost, and thus they could not be represented as being from the Government breeding station here. When this contract with the Government comes for revision I would be inclined to suggest some minor changes. As an administrative matter there should not be ambiguity concerning those relations to the Station and to the College. The

present ambiguous condition has rendered it possible to interpret so that knowledge of the development or progress has not been on record either in the office of the Secretary, President or Director.

FUTURE DEVELOPMENT OF THE STATION.

A large part of the recent meeting of the College and Experiment Stations was taken up with the consideration of the question of research, and Station organization and policy. These questions have become of greater importance with the changes brought about by the Adams fund. Nearly all of the Stations are feeling the effects. A noticeable fundamental effect is the changed outlook upon scientific work. The Hatch appropriation was considered as secondary to college work. The tendency was to take up chemical work or entomological work, or any other line, because the College had a chemist or an entomologist. The fund was looked on somewhat as a means to obtain superior men for College work and to help pay them. The fund was therefore looked upon as an addition to the College.

The Adams act and its requirements change this. It now makes the scientific project the unit and bigger than the man The chemist, for instance, is now employed because chemical investigations are required. The changes thus introduced in the outlook of the Station and its relation to the College will be fundamental, and will cause the Experiment Station of the United States to occupy a very different position in the course of a few years. It is not at present a question whether we look on these changes as desirable. They seem to be inevitable if the law remains as it is, and there seems to be no probability that any change will be made. With the increased revenue of the Stations, and this change in outlook, and the additional supervisory power given to the Department of Agriculture, the Stations will become more and more institutes of research in the narrow sense. The requirements of the Adams bill will react upon the Hatch fund, and will undoubtedly alter the view of many scientific investigators.* There is no doubt that we have been undertaking too much and that much more has been attempted by each man than he could do. The work of teaching has generally been considered primary, and such investigational work as has been done has been done at odd times or in vacations and as a secondary matter. If there was conflict the teaching kept the first place, and this meant that the Station work suffered.

---

*In the Experiment Station Record for December, issued since this report was read, the U. S. Department of Agriculture says that a stricter interpretation will be given the Hatch Act, and "no longer to permit expenditures from that fund for Farmers' Institute work, extension teaching or the preparation of compilations."

It is to be expected that the Government will require the Institutions to provide the best conditions for scientific work, and that the men who are on the Adams fund must consider this work as primary. If there be conflicts between the scientific work and teaching, for instance, then the Government is in position to insist that the scientific work shall not suffer. These changed conditions, therefore, are affecting other Stations as well as our own, and makes this a period of transition from the former loose basis to the future one where scientific investigations will be primary. The Stations are working this out, but as yet have not all reached the same conclusions as to method.

The general recommendation for carrying out the policies is toward reducing the number of lines of work; to select a few important subjects and then to let the work of the various men cluster about these projects. This prevents some of the distribution of effort on unimportant work, which may seem to be popular, but is unimportant in the long run. The tendency is to reduce the amount of teaching. Nearly every investigator is also a good teacher, and, under pressure of demands as well as his own impulse, he is apt to teach more than is desirable. Teaching even an hour a day breaks up the continuity of the investigator's work of the highest class. Extension work and work of Farmers' Institutes, and likewise work which is called popular, is apt to be in conflict. There is often pressure for Stations to do inspection work, as the inspection of fertilizers, injurious insects, animal diseases, etc. All of these are proper in their own line, but also are considered objectionable. Each of these questions bring up serious matters for consideration. Some Colleges are taking the position that the Experiment Station should be entirely separate from the College, and thus have, for example, two chemists and a duplication of other officers, so that the teacher does not investigate and the investigator does not teach. It is in this way that some of the Institutions interpret the provision of the law that the Station shall be a department of the College. In others, like our own, the Station work is a part of several departments, and the various departments are the unit. There is carried on in each department both teaching, investigation and extension work. While the majority of institutions are separating the Stations, I am inclined to think that our arrangement is better for our conditions, at least for the present, both for the College and for the Station.

A Committee of six of the most prominent Directors in the United States formed a committee on Station organization and policy. Their report, or even their conclusions, is too long to repeat. Concerning inspection work the committee recommend that this be kept entirely separate from scientific work, and that if it be undertaken that it be from separate

funds. They recommend that the investigator should be free from the routine of teaching, and further recommend in their conclusions that the ideal policy would be for the investigator to be free from such responsibilities, and, as a step, that the teaching be limited to a maximum of three hours per week for one term in each year, and that this be along the lines of his specialty.

This report and also the report by the Committee on Scientific Research, of which David Starr Jordan, of California, was chairman, will be read in full to the members of the Station Staff.

The reprint of this Committee is too long for quotation, but their conclusions which were accepted as the conclusions of the association deserve weight as the conviction of men who are giving much attention to these problems, and is worth quotation as bearing on the general question of Station policy reached in the study of relation between research and administration and also upon the matters affecting the continuity of Station work.

RELATION BETWEEN RESEARCH AND ADMINISTRATION.

"(1) The station exists primarily for research in the interest of the public service. If, however, this research is to be made effective there must be administration as well as investigation, and both reason and the dictates of justice demand that the scientific worker and the administrative officer be mutually sympathetic and helpful each to the other.

(2) The unit of work is the individual, and nothing should come between him and his research. That organization is best, therefore, which most accurately defines the field of each station worker, protects him in his investigations within that field, insures funds and equipment for the pursuit of research, and in the end secures results that are useful to the public that pays the bills.

(3) Administration as such does no work. At best its function is correlation as between internal interests on the one hand and as between these and the external or public interests upon the other. In theory all administration means delay and some necessary interference with individual initiative. This is unfortunate, but inevitable, though its compensation lies in the increased certainty that interests will not clash within and that the public needs may be well served, an end that requires the counsel of many minds. In interests of work, therefore, the less administration the better, if only the proper ends are attained, but workers must recognize the necessity of something like organization, which means administration.

(4) The chief functions of administration in respect to a piece of investigation may be enumerated as follows:

(a) To help to determine in advance whether the proposed research is profitable and altogether advisable from the stand-

point of the public, whose representative for the time being the administrative officer must be.

(b) To assist in determining what lines of experimentation are calculated to throw profitable light upon the problem.

(c) To help to determine whether the work is best carried on by one individual representing a single line of inquiry, or by two or more working in conjunction, and if the latter, to secure in advance a complete understanding as to mutual duties, rights, and responsibilities. Upon all these points the judgment and the point of view of the administrative officer is not only likely to be broader, but certain to be freer from personal bias than is that of the professional investigator.

(d) The experiment once decided upon, however, and the funds provided, administration is over until results are due, when it begins again and does not cease till reports are published and circulated. The less administration during the progress of the work the better for all interests, and if the need of it becomes clear it is the best of evidence that administration was remiss at the outset. Your committee cannot too strongly point out the necessity of the entire freedom as to methods of investigation on the part of the staff worker who has been employed because of his expert knowledge of the matter and methods of work in a highly specialized field.

(5) To secure these two ideals of administration efficiency and sympathetic helpfulness without interference requires for administrative officers men not only of good business methods and large outlook, but also with the highest obtainable training along some important line of science as related to agriculture.

(6) If the organization be large the department plan will of necessity be employed, and administration will be exercised largely through the head of the department. Besides his administrative function the department head will have, or should have, a special line of his own, and as he himself values a free field with no interference, so should he accord the same privilege to every member of his department; that is, he should take no advantage of his administrative superiority to invade the field of work of another. Such an individual, exercising the double function of administration and work, must needs exercise great care as to when he operates under the one capacity and when under the other.

(7) This principle is best fixed by an illustration in a large department, containing men of all degrees of proficiency, from the novice with the title of assistant up to the skilled investigator with a title equivalent to that of full professor. Over the one the department head must needs exercise much supervision, even to the point of daily direction, but over the other he only injures the work by presuming to direct. The point is that when an officer, holding the double function of worker and of administrator, directs the work of another he does it not

as an administrative officer, but as a department superior directing his assistant.

(8) The principle applied to the director means that as director he is not responsible for and should not attempt to control, much less direct, the details of procedure in a scientific investigation. Again, the principle gets its best illustration in a case where the staff worker is not only entirely capable of conducting the details of research, but is greatly the superior of the director himself as to skill in scientific method. Such cases are not rare; indeed, if our stations were equipped, as they should be, with large numbers of strong and independent men, this would be the common occurrence, in which case the director could not presume to expert knowledge in all its various fields of research and experimentation.

(9) If the station be small, the director occupies much the position of a department head, and if the workers are young and inexperienced, he will of necessity keep close to the work. Nevertheless, it is even then better for the director to carefully refrain from exercising administrative pressure or authority in respect to investigations and couch his influence in terms of advice and sympathetic assistance. This is the only way to develop strong investigators from young men, as it is the only way to deal with investigators if they are strong already, and until we can fix the principle that in station work the labors of the scientist shall be free from administrative interference, we shall not be able to attract into agriculture the ablest men or to hold them when we get them. Your committee is credibly informed that instances are not wanting in which good men have left the work because the director felt free to criticise, even to direct, in scientific details about which he knew practically nothing.

(10) As a means of establishing and maintaining a strong organization without a galling and depressing effect of too much administration, three things are helpful: First, that every administrative officer fully respect the position of every other, whether superior or inferior, and never go around him for any purpose whatever; second, that a regular succession of administration be established, so that, in the absence of any officer, another at once steps into his place, exercising not quasi, but actual, authority so long as he occupies the position, all of his acts to be as fully respected as are those of the regular appointee; and, third, that there be frequent and full conferences between administrative officers and all others where work and administrative duties come together. In all these ways a full understanding will be assured, and nearly everybody, at some time or other, will get some experience with administration.

(11) The committee does not favor a weak organization, but, on the other hand, one that is strong enough to recognize the interests of the whole Station as above those of any other department or separate interest, and strong enough to enable the entire

influence of the whole body to be exerted in any desired direction on short notice. If this is to be accomplished, everybody must feel free, and not the object of arbitrary rulings. The test of the esprit de corps of such an organization is whether or not it will support, as it should, a position that needs to be taken by the highest administrative officers."

CONTINUITY OF STATION WORK.

"The following are claimed to be some of the frequent causes of lack of continuity of effort:

(1) Too frequent changes in the working force.

(2) The dropping of work before its completion in the effort to meet some actual or supposed popular clamor for new lines of investigation.

(3) Insufficient and too infrequent advances in the salaries, particularly of the older men, and their consequent withdrawal to accept more lucrative positions elsewhere.

(4) Lack of equipment and facilities for investigation; for example, the lack of fields for experimental work at the outset, involving shifting from one place to another; also delay in undertaking some of the most vital problems and the necessity of taking up less important lines of work as temporary expedients.

(5) Government by a Station council rather than by a director, resulting in a change of policy with changes in the personnel of the council.

(6) The assumption, in some cases, of the function of the director by the president. For example, relief of the director from all financial responsibility, a policy which deserves strenuous discouragement.

(7) The amount of teaching and extension work required of Station officers.

(8) The forcing upon the stations of men in the colleges who are not adapted to do research work.

(9) The occasional appointment of incompetent men as directors or heads of departments, which necessarily involves poorly planned experimental projects and necessitates changes at a later date; also the appointment of politicians and of others for political or personal considerations.

(10) Occasional sudden changes of entire boards of management in certain states and territories, resulting frequently in abrupt and most serious changes in policy.

(11) Undertaking too many lines of work and attempting to cover too wide a field."

Under the terms of the Adams act the projects undertaken are subject to the approval of the Government, and, after once undertaken, it is then almost necessary for the Station to carry them through. We are limited in the expenditure of money to

the approved projects and to the necessary equipment and expenses in connection therewith. This helps to force a continuity of effort and carefulness in planning. Thus, last winter, when it became evident that some lines of work which had been planned in plant diseases could not be carried out by Professor Paddock, this pressure made it necessary to consider how the work could be carried on, and led eventually to the necessity of obtaining a special bacteriologist, Mr. W. G. Sackett, who was employed entirely at the expense of the Adams fund, and who gives his entire time to Adams fund investigations. There has been considerable desire for him to teach, but, manifestly, this could not be done until arrangement was made for paying at least a corresponding part of his salary from other than Station funds. The arrangement with Mr. Sackett was that he was to come at $1,600 per year, and that, if satisfactory, he should be raised to $1,800 by the end of the year; and, as this has been the case, I would recommend that, starting from the first of January, his salary be $1,800 from the Adams fund. If it be desirable that he teach during the winter term, then that $1,500 be paid from the Adams fund and $300 from the College funds.

Some of the special problems which are brought about by our Station organization are those relating to the staff and the calls of the College. There are some who are paid only a small amount from the Station, and some who are paid none at all, and some who are paid a large amount from the Station. The tendency has been to increase the amount paid by the Station to those who are devoting a large part of their time to scientific work, and especially to Adams fund work. The general experience seems to be that it is better to obtain fewer men and to pay a larger part of their salaries from this fund. The pressure toward reducing the amount of teaching necessarily means that some others in the same department must spend a larger amount of time in teaching. This creates some dissatisfaction, as there is a triple standard to which the different members are held. Some are inclined to think that the whole duty of the professor is to teach. People who attend the farmers' institutes are disappointed unless they hear the heads of the departments. The larger world will judge a man by his Experiment Station investigations. It is impossible for the heads of departments to meet all of these demands. The tendency has been for one to still be the responsible head and to direct the general work, and to be relieved of some of the routine work, so as to be able to give such time to the problems on which he is working. The general conditions may force a reduction in the number of the Experiment Station staff, but this is not, perhaps, to be desired. There are, however, a number who have been paid a small sum—for instance, $100 per year—partly as a means of saving embarrassment in the departments. It is a question whether, from the Station standpoint, this course is advantageous. As it has been in the past, the Station men have

received less pay than those on the College, where the requirements are greater, and, as a whole, they have been held to more strenuous requirements; so, in departments where some men are on the Station roll, some on the College, the fact that the College men are relatively free concerning their hours, and may be entirely free during the summer vacation, has sometimes caused complaint among the Station men. It is undoubtedly proper for the College to aid the Station, either by direct appropriation or by paying men who may be assigned for more or less of their time to Station work. The law, however, does not permit the Station to pay men for the purpose of aiding the College. It might be considered that the expenditure by the College has been more than offset by the fact that the Station appropriation enables the College to do work that its own funds have not been sufficient to do. I doubt if the practice of paying a small sum to meet this embarrassment is good policy. The embarrassments that have arisen in times past have been brought to your attention before. They involve some questions of College policy, and may lead to a question of special understanding with each person. So far as the question involves the Station, the embarrassment may be relieved if the Board should see fit to rule that those who are in departments forming sections of the Experiment Station should be under the direction of their chief during the summer as well as during the rest of the year. There would still remain some dissatisfaction as between such departments and those where work is not carried on at all during the summer.

The adjustment of teaching so as to be of best value to the department and Station is another matter that will gradually work its way out.

Is it proper for the Station to print popular bulletins of information, especially from the Hatch fund? There is undoubtedly a call for these. How is that to be met and to what extent should Station people do such work? There is undoubtedly a feeling among Station men that the so-called popular work is not the proper work for the Station investigator, and it is evidently the belief that fundamental work is of more importance. There is also a lingering doubt in the minds of Station workers of the expediency of trusting themselves too entirely to scientific work because of the feeling that there is not at present a proper recognition by the public and by the Boards of Control of what constitutes scientific work and therefore proper moral support.

Foreseeing these questions I have given a good deal of thought during the past few years to the development that was eventually coming. In many cases I have not reached conclusions that I am satisfied are best. The change, however, is taking place as fast as conditions require it, and all the Stations in the United States are working at the solution of the same general questions. As I called to your attention some

years ago, the fact of the passage of the Adams act would not be to relieve the College finances as was hoped, but increased our responsibilities more than it increased our revenue.

The tendency undoubtedly will be to reduce the lines of work, but may require as many, if not more, people. Thus, for instance, in the past we have done something concerning alkali from the chemical side, because we had a chemist on the Station. Now the tendency would be to take up the alkali question, for instance, and then the different members of the Station would work in unison upon that problem. The chemist from the chemical side taking up the chemical features; the bacteriologist the side of bacteria of alkaline soils; the irrigation engineer from the standpoint of drainage and of prevention, and perhaps the botanist from the standpoint of determining what vegetation may be grown on alkaline soils, etc.

Thus with this development the different Stations would take up different general questions. Some Stations become known for their work in feeding, and the results of such investigations would be valuable everywhere; other investigations in fruit questions; and other investigations in poultry culture.

Our conditions in this State, the development of our State, has made irrigation the foundation question, and our natural development is on the lines related to it. This does not mean that such is the only question, but on it we stand under unique conditions.

RECOMMENDATIONS.

The general statements above show in some degree the character of the questions that have had to be considered in a broader way in the year past, and some of the tendencies which I think are affecting us, and will cause a readjustment of Station work. We will have to settle some of these in the light our own conditions. Many will settle themselves as fast as can be expected.

There are comparatively few matters that I have to bring up for direct recommendation. One is concerning the salary of Mr. Sackett, that provision be made to raise it from $1,600 to $1,800 per year, beginning with the first of January.

I would recommend that a determination be made of what should be asked from the Legislature. This list attached is simply a memorandum as a basis for consideration.

In the above report I have called attention to conditions, but have not attempted to make specific recommendations, for most of these I think are in condition to solve themselves, with some patience and some guidance.

As a whole the problems in this State are interesting and important in character, and the work that the Station has done has met recognition both here and elsewhere. In the long run

the Station will be judged by the work of a thoroughly scientific character, which may or may not be popular at the time. It is, however, this kind of work that is the fundamental work for the Station's usefulness. The so-called popular work must be founded on the scientific work, and the scientific work must, therefore, go ahead of the popular work.

The distribution of the results through extension or demonstration work, is a duty that is owed to the people, but, as I have attempted to show, is only to a limited extent chargeable to the Government funds, therefore, must be supplemented by State appropriations or other sources of revenue.

Prospects are bright, and while the Station and its work is in the transition period, yet it will be worked out under conditions as they develop with the purpose of being of the greatest value to the agricultural interests of the State.

The reports of the separate sections are collected and give many details of work not here referred to. Request was made early in October for reports, but none were presented by those whose responsibility ceased in that month.

Respectfully submitted,

L. G. CARPENTER,
Director.

NEEDS.

1. Fruit Investigation, past appropriation $8,000, only sufficient for the payment of the men at Delta and Grand Junction. The scope of the bill is broader and something ought to be done in other parts of the State. The amount ought to be at least $10,000.

2. Plant Industry, for the last two years $6,000. This does not pay any salaries, and includes $2,000 for building. This amount is not large enough, and ought to be either $8,000 or $10,000.

3. Animal Industry, $6,000 for the past two years. It ought to be as much for the coming two years, or probably more. The previous sum was available both for investigations concerning stock, also concerning feeds and feeding. The feeding problem is important enough to be considered separately, and I would recommend that a separate sum be asked for experiments in feeds and feeding.

4. The potato investigation did not have an appropriation the last biennial period. We had $1,000 for the biennium before. The Experiment Station has paid $600 of the salary of Mr. Bennett, and the College has paid the rest of the sum. Part of the expenses have been borne by the Station. This work is largely of the nature of teaching and extension work. This work should require for the

two years $6,000. This would only allow $1,200 besides salary, and would be sufficient to publish one bulletin, and pay the field expenses.

5. Animal Diseases. $500 received for the last biennial period. The development of the Veterinary department has largely taken the time of Dr. Glover. If an appropriation could be had there might be a start made in the distribution of serum for hog cholera, and special investigation of other diseases. This serum distribution is not a proper charge on the Experiment Station funds.

6. Farm Mechanics, $2,000 received during the past biennial period, of which one-half was used for building. There is still a balance of $600.

7. Horse Investigation, $5,000 was received. There are beginning to be some receipts, but nowhere near enough to maintain this breeding work. There ought to be as much more available during the next two years. There is a balance of $1,500. No salaries have been charged to this fund. There was $1,000 used for land; a large part of the rest has been used for equipment in the way of sheds, feeding racks, fences, etc.

8. Irrigation Investigations. Nothing was asked for in the previous period. This can be one of the most fruitful lines, and a systematic investigation of the water resources and application of water would be of very great benefit, and I would therefore recommend that from $6,000 to $10,000 be asked for for this purpose.

9. Lands. This previous bill provided for $7,500 for lands. The College is in debt for a large amount and it would be desirable to obtain as much as possible.

10. Building and equipment of the Irrigation Building. To complete and equip the building would require at least $70,000.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1908.

RECEIPTS.

DR.

From the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1908, under acts of Congress, approved March 2, 1887	Hatch Fund.	Adams Fund.	State Fund.	Special Fund.	Totals.
(Hatch Fund), and March 16, 1906 (Adams Fund)	$15,000.00	.....	.....	.....	.....
	.....	$ 8,756.22	.....	.....	.....
Appropriation by State Legislature	.....	.....	$27,500.00	.....	.....
Balance on hand July 1, 1907	.....	.....	.....	$ 842.33	.....
*Transfer	.....	.....	.....	3,716.18	.....
Other sources than the United States	.....	.....	.....	9,164.85	.....
Total receipts					$64,979.58

DISBURSEMENTS.

By Salaries	$ 9,273.16	$ 5,749.78	$ 1,647.50	$ 1,045.00	$17,715.44
Labor	620.80	5.45	1,548.86	867.43	3,042.54
Publications	3,042.55	.....	.....	.....	3,042.55
Postage and Stationery	337.94	9.32	212.45	62.55	622.26
Freight and Express	112.20	107.58	192.78	214.19	626.75
Heat, Light, Water and Power	.....	120.64	14.85	16.00	151.49
Chemical Supplies	137.80	175.35	1.00	14.90	329.05
Seeds, Plants and Sundry Supplies	48.58	103.17	420.26	57.53	729.54

Fertilizers	.....	.....	.....	.....	.....
Feeding Stuffs	.....	.....	1,084.89	434.77	1,519.66
Library	165.86	25.53	.....	107.23	298.62
Tools, Implements and Machinery	2.75	3.00	56.10	557.30	619.15
Furniture and Fixtures	565.60	555.35	17.80	111.75	1,250.50
Scientific Apparatus	37.97	942.25	98.23	51.36	1,129.81
Live Stock	.....	15.80	1,652.34	1,642.39	3,310.53
Traveling Expenses	489.79	493.00	251.90	446.70	1,681.39
Contingent Expenses	15.00	.....	343.78	184.25	543.03
Buildings and Land	50.00	450.00	1,943.85	602.35	3,046.20
Total Expenditure	$15,000.00	$ 8,756.22	$ 9,486.59	$ 6,415.70	$39,658.51
†Transfer			4,986.02		4,986.02
			$14,472.61		$44,644.53
Balance			13,027.39	7,307.66	20,335.05
			$27,500.00	$13,723.36	$64,979.58

*Special appropriation by State Legislature for the two years from December 1, 1906, to November 30, 1908, inclusive.

†To reimburse for funds advanced before funds provided for by Legislative appropriation became available.

Advanced from College Funds	$1,269.84
Advanced from Special Funds	3,716.18
Transferred from Appropriation	$4,986.02

BULLETINS ISSUED DURING CALENDAR YEAR OF 1908.

No. 126. Cantaloupe Breeding, by P. K. Blinn.

No. 127. Climate of Colorado, Temperature 21 Years' Record at Fort Collins, by L. G. Carpenter and R. E. Trimble.

No. 128. Alfalfa Studies, Progress Report, by P. K. Blinn.

No. 129. Extraction of Beeswax, by F. C. Alford.

No. 130. The Evergreen Trees of Colorado, by B. O. Longyear.

No. 131. Arsenical Poisoning of Fruit Trees, by Wm. P. Headden.

No. 132. Destruction of Concrete by Alkali, by Wm. P. Headden.

No. 133. A Few Orchard Plant Lice, by C. P. Gillette and E. P. Taylor.

No. 134. Orchard Plant Lice and Their Remedies, by C. P. Gillette and E. P. Taylor.

No. 135. Australian Salt Bush and Notes on Russian Thistle, by Wm. P. Headden.

BULLETINS ISSUED DURING YEAR 1908.

No.	Pages.	Edition.	Total No. of Pages.
126	10	15,000	150,000
127	12	15,000	180,000
128	8	15,000	120,000
129	16	15,000	240,000
130	32	15,000	480,000
131	28	15,000	420,000
132	8	10,000	80,000
133	48	5,000	240,000
134	16	15,000	240,000
135	16	10,000	160,000

EXCHANGES.

BOOKS, PAMPHLETS, SCIENTIFIC PROCEEDINGS, ETC., 1908.

AUSTRALIA:

Journal of Department of Agriculture, Victoria.

Bulletins 31-40, inclusive.

AUSTRIA:

Sugar Beet Seed Breeding Station.

CANADA:

Appendix to Report of Minister of Agriculture; Experimental Farms.

Bulletins 57, 58, 59, 60.

Experimental Farm, Lethbridge, Alberta; Alfalfa Growing.

Le Naturaliste Canadien.

Annual Report of Department of Agriculture, Province of Saskatchewan.

Report of Cattle, Horse and Sheep Breeders' Association.

Report of Department of Agriculture and Immigration.

CUBA:

Circular 27, Black Leg and Vaccination.

Circular 29, Wounds of Animals and Their Treatment.

Bulletins 9, 10, 11.

ENGLAND:

Bulletins 177, 178, 179, 183, 187, 188, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204.

Circular 18.

Production of New Types of Forage Plants, Clovers and Grasses.

Report on Injurious Insects in Midland Counties.

Journal of Royal Horticultural Society.

FRANCE:

Journal d'Agriculture Protique, Paris; September, October, November, December.

FINLAND:

Berattelse ofver Skadeinsekters upptradande i Finland.

GERMANY:

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 5.

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 3.

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 4.

Station fur Pfanzonschutz ozu Hamburg Sonderdruck 9.

Notizblatt des Konigl botenischew Gartens und Museums zu Berlin—Gaglenn, Index and Appendix 1 to 9.

Bulletins 1 to 42.

EXCHANGES—Continued.

INDIA:

Memoirs of the Department of Agriculture in India.

Annual Report of Agricultural Chemist.

The Agricultural Journal of India.

ITALY:

R Stazione Di Patologia Vegetale, Studi sul Marciune delle radici nelle viti fillosserate.

Bolletino della Arboricoltura italiana.

JAMAICA:

Department of Agriculture.

JAPAN:

Bulletin of the Imperial Central Agricultural Experimental Station, Japan.

The Insect World, Gifu, Japan.

MEXICO:

El Agricultor Mexicano La.

La Reproduction Del Ganado Vacuno, Chihuahua.

Algunas Plantas Forrajeras.

Veinte Plagas De La Agricultura.

Los Silos Economicos.

La Canagria.

Cantidad De Agua Necessaria Para Riegoo.

NEW SOUTH WALES:

The Agricultural Gazette, Sydney.

Report of Second Session, Legislative Assembly; Botanic Gardens and Government Domains.

Improvement of Cereals by Crossing and Selection.

NEW ZEALAND:

Extracts from Fourteenth Annual Report; Reports of 1906, Experiment Station.

Bulletins 1, 2, 5, 10, 12, 16, 17, 18, 19.

Leaflet 10.

Agriculture in New Zealand.

Fifteenth Annual Report of Department of Agriculture.

Poultry Report.

Report of Division of Biology, Horticulture.

New Zealand Official Year Book.

Agriculture in New Zealand.

Immigrants' Guide and Settlers' Hand Book.

EXCHANGES—Continued.

SOUTH AMERICA:

Boletin da Agricultura. Sao Pauls.

Boletin del Ministerio de Fomento, Lima, Peru.

Boletin del Ministerio de Agricultura, Biunos Aired.

Boletin da Agricultura.

Boletin del Ministerio de Fomento, Lima, Peru,

A Lavoura Boletinda Sociedade de Agricultura; December, January.

Boletin da Agricultura.

Boletin del Ministerio de Fomento, Lima, Peru,

Boletin da Agricultura.

A Lavoura, Boletin da Sociedade Nacional de Agricultura.

Boletin del Ministerio de Fomento.

O Criador Paulista.

Boletin de Agricultura.

Boletin da Instituto Agronomico.

Boletin y Registro Official de la Dirrecion Obras Publicas e Irrigacion.

Anales de Muses Nacional.

Ballettino Arboricottura Xlatiana.

Cronica Agucila.

SOUTH AUSTRALIA:

Journal of Department of Agriculture of South Australia.

The Codling Moth; Results of Experiments with Arsenate of Soda.

Butter and Cheese Factories, Milk Stations and Condensories.

Bureau of Horticultural Inspection, New York.

Transactions of Massachusetts Horticulture Society.

Journal of Department of Agriculture of South Australia. (Adelaide.)

Bulletin 27; Roseworthy Agricultural College; Second Report on the Permanent Experimental Field.

Bulletin 29; The South Australian Wheat Yield Season.

Report of Department of Agriculture and Intelligence.

Boletin del Ministerio de Fomento.

Notes on Agriculture in South Australia.

SOUTH AFRICA:

The Transvaal Agricultural Journal.

SPAIN:

The Great Millet or Sorghum in Madras; Bulletin 55.

SWEDEN:

Tidskrift No. 405.

No. 12, Uppsatser Praktisk Entomologi, Stockholm.

No. 13, Uppsatser Praktisk Entomologi, Stockholm.

EXCHANGES—Continued.

No. 14, Uppsatser Praktisk Entomologi, Stockholm.

No. 15, Uppsatser Praktisk Entomologi, Stockholm.

No. 16, Uppsatser Praktisk Entomologi, Stockholm.

No. 17, Uppsatser Praktisk Entomologi, Stockholm.

Handlinger Och Tidskrift, Stockholm.

Journal of Agriculture, Volume 4.

Chemistry as a Factor in Agriculture. (Melbourne.)

Journal of Agriculture, Volume 3.

Closer Settlements Regulations Governing the Acquisition and Disposal of Lands.

The Victoria Settlers' Guide and Hand Book of the Land Laws.

Orchard Pests and Their Treatment.

The Journal of Department of Agriculture, Volume 5.

UNITED STATES:

Annual Report (30th), Providence Public Library.

Annual Report (31st), State Board of Health, New Jersey.

Annual Report of State Board of Horticulture of Missouri.

Annual Report of Michigan State Board of Agriculture.

Bulletin, Georgia Department of Agriculture; Commercial Fertilizers.

Bulletin, Department of Agriculture of Pennsylvania.

Bulletin, Marathon School of Agriculture, Etc., Wausau, Wisconsin.

Bulletin, North Carolina Department of Agriculture; Report of Farmers' Institute.

Bulletin, North Carolina Department of Agriculture; Stock Feeds.

Bulletin No. 14, New York Botanical Gardens, No. 19.

Bulletin, State Horticultural Society; Plants of Iowa. (Des Moines.)

Bulletin, State Board of Health of Maine.

Bulletin, Wisconsin Natural History Society.

Bulletin, North Carolina Department of Agriculture.

Cornell Rural School Leaflet; Ithaca; Nos. 1 and 2.

Crop Reporter.

Clarkson Bulletin.

Colorado Scientific Society; Esperanto and its Availability for Scientific Writings.

Department of Agriculture of Alabama; Report on Fertilizing and Soil Surveys.

Department of Agriculture of Maine; The Orchards of Maine.

Florida Quarterly Bulletin, Tallahassee, Florida.

Georgia State Board of Entomology; Circular No. 6.

Georgia State Board of Entomology; Bulletin 25.

EXCHANGES—Continued.

Georgia State Board of Entomology; Peach Leaf and Yellows.

Georgia State Board of Entomology; Circular No. 8.

Journal of New York Entomological Society, New York City.

Journal of New York Botanical Garden.

Kentucky Crop Report.

Laboratory Bulletin 13, Oberlin, Ohio; Development of Nestling, etc.

Long Island Agronomist.

Maine Department of Agriculture.

North Carolina Department of Agriculture; Feeding Stuff Laws.

North Carolina Department of Agriculture.

Pure Products.

Proceedings of the Colorado Scientific Society.

Plants of Iowa; Bulletin of State Horticultural Society.

Production of Lumber, Lath and Shingles.

Report of Secretary of Canadian Seed Growers' Association, Ottawa, Canada.

Report of Kansas State Board of Agriculture.

Report of Kansas State Board of Agriculture.

Report (18th), Missouri Botanical Gardens.

Report of the Kansas State Board of Agriculture.

Report of the West Virginia State Board of Agriculture.

Report and Catalog of Louisiana State Museum.

Report (4th), Biennial, Montana State Board of Horticulture.

State Crop Pest Commission of Louisiana; Circulars Nos. 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21.

Smithsonian Institute; United States National Herbarium Studies of American Tropical Ferns.

Training School.

Transactions of Iowa Horticultural Society.

Transactions of Massachusetts Horticultural Society.

Therapeutic Notes.

Tuberculosis in France; Daily Consular and Trade Reports.

University of Illinois Bulletin; A Study of Roof Trusses.

University of Illinois Engineering Experiment Station; Comparative Tests of Carbon, Metallized Carbon and Tantaleum Filament Lamps.

University of Illinois Engineering Experiment Station Bulletins.

Wilson Bulletins.

Wisconsin State Horticultural Society. (Spraying.)

Year Book, Rubber Planters' Association of Mexico.

Zoological Bulletins.

EXCHANGES—Continued.

SCIENTIFIC PERIODICALS:

Insect World, Gifu, Japan.

Kungle, Landtbrusk-Akademiens Handlinger Och Tidskrift, Stockholm, Sweden.

Le Naturaliste Capadieu, Chicoutimi, Quebec, Canada.

AGRICULTURAL JOURNALS:

American Miller, Chicago.

American Farm World, Augusta, Me.

Agricultural Southwest, Wichita, Kan.

American Sugar Industry and Beet Sugar Gazette, Chicago.

Agricultural Advertising, Chicago.

Agricultural Epitomist, Spencer, Ind.

American Hay, Flour and Feed Journal, New York.

American Fertilizer, Philadelphia.

American Farm Review.

Colorado Fruit Grower, Paonia.

Colman's Rural World, St. Louis.

Elgin Dairy Report, Elgin, Ill.

Farm Scientist, Chicago.

Farmers' Guide, Huntington, Ind.

Farmer and Breeder, Sioux City, Iowa.

Farmers' Tribune, Sioux City, Iowa.

Farm Stock Journal, Rochester, N. Y.

Fruit Grower, St. Joseph, Mo.

Farmers' Advocate, London, Ont.

Farmers' Review, Chicago.

Farm Stock and Home, Minneapolis, Minn.

Farm Progress.

Farm and Stock, St. Joseph, Mo.

Farm Life, Chicago.

Farm and Home.

Farmers' Digest.

Fruit Grower, St. Joseph, Mo.

Homestead, Des Moines, Ia.

Indiana Farmer, Indianapolis.

Kimball's Dairy Farmer, Waterloo.

Live Stock and Dairy Journal.

Missouri Agricultural College Farmer, Columbia, Mo.

Metropolitan and Rural Home.

Modern Farmer, St. Joseph.

EXCHANGES—Continued.

Modern Miller.
Minnesota and Dakota Farmer, Brookings, South Dakota.
Modern Farming, Richmond, Va.
Jewish Farmer.
Iowa Horticulture.
New Southwest, The, St. Louis, Mo.
National Farmer and Stock Grower, St. Louis.
New Zealand Dairyman, Wellington, N. Z.
Nebraska Farmer, Lincoln, Neb.
National Stockman and Farmer, Buffalo, or Chicago.
Nebraska Farm Journal, Lincoln, Neb.
Nut Grower, The.
Oklahoma Agriculturist, El Reno, Okla.
Practical Fruit Grower, Springfield, Mo.
Pacific Fruit World, San Francisco.
Poultry Husbandry, Waterville, New York.
Prairie Farmer, Chicago.
Planters' Journal, Memphis, Tenn.
Ohio Farmer, Cleveland, O.
Orange Judd Farmer, Chicago, Ill.
Ruralist, The, Sedalia, Mo.
Rural Home, New York, N. Y.
Rural New Yorker, N. Y.
Rural World.
Rural Advocate, Battle Creek, Mich.
Ranch News, Denver, Colo.
Strawberry, The, Three Rivers, Mich.
Southern Farm Magazine, Baltimore, Md.
Southern Agriculturist, Nashville, Tenn.
Successful Farming, Des Moines, Iowa.
Station Farm and Dairy, Sydney, N. S. W.
Surface Creek Champion, Cedaredge, Colo.
Southern Planter, The, Richmond, Va.
Texas Farmer, Dallas, Tex.
Wallace's Farmer, Des Moines, Iowa.

NEWSPAPERS:

Fort Morgan Times, Fort Morgan, Colo.
Illuminated World Life.
Mark Lane Express, London, England.
Palisade Tribune, The, Palisade, Colo.

EXCHANGES—Concluded.

Pueblo Chieftain.

The Republic, St. Louis, Mo.

The Salt Lake Herald, Salt Lake, Utah.

WEATHER BUREAU:

Colorado Section.

Illinois Section.

New England Section.

New Mexico Section.

Oregon Section.

Wyoming Section.

REPORT OF THE ENTOMOLOGIST.

To the Director:

I beg to present herewith the annual report of the entomological section of the Experiment Station for the year now closing. The various projects for the year have been under the Hatch fund, the Adams fund, and the general fund and are referred to separately below.

HATCH FUND.

Project 1. Miscellaneous Insect Pests. This project was proposed to enable the section to give such attention as might be necessary to unusual or unexpected insect outbreaks that might occur during the year, both for the purpose of accumulating information concerning them and also for the purpose of testing methods of keeping the insects in check. There has been very little call for special work in this line during the year.

The Beet Plant Louse (Pemphigus betae) has occurred in unusual numbers in the Arkansas Valley and in a portion of the beet raising section in the northern part of the State, and considerable attention has been given to the louse for the purpose of determining some points in its life history, the extent of its injuries, both to the farmer and to the sugar companies, and possible means of prevention or remedy.

The Clover Louse (Aphis bakeri) has also been unusually numerous on the Western Slope and has attracted considerable attention in the orchards. We have succeeded in working out its life history quite fully, and also the remedies that should be applied to keep it under control. The life history of this louse was very imperfectly known before.

Two of the vegetable feeding mites, commonly known as the red spider and the brown mite, have also been quite destructive this year, especially to raspberry bushes on the Western Slope. Mr. Weldon gave some special attention to a test of remedies for destruction of the mites and met with good success.

While the work upon the lice here mentioned might also be placed under the Adams fund project, I am placing it here because of the unusual outbreaks of these insects calling for special attention.

Project 2. Collecting and Rearing Insects. Nearly all the work under this project during the past year has been confined to the plant lice and their enemies. A small number of other insects have been taken as good opportunities presented themselves, all of which have been properly labeled and placed in the insect collection.

We now have one of the largest collections of plant lice in the West, and perhaps the largest collection of western plant lice to be found anywhere, including close to 1,000 balsam mounts and a somewhat larger number of alcoholic vials. These lice are in greater part determined to species and systematically arranged for study.

Project 5. Experimental Orchard. The objects in putting out an experimental orchard were: First, to have a good number of orchard trees that might be used in an experimental way for the purpose of rearing insects and testing various methods for their control. The trees have done well this year; we have infested them quite thoroughly with the green aphis and the woolly aphis for experimental purposes, and have succeeded in rearing the sexual forms and obtaining a good number of eggs of the latter species.

Project 7. The Potato Flea Beetle. The work under this project is a continuation of work that has been carried on by Professor Johnson for the past two or three years upon this insect. Professor Johnson hoped to be able this year to complete his observations upon the life history of the insect and to test a few remedies in a large way in the field. The testing of remedies was rendered impossible so far as obtaining satisfactory results is concerned, because of a very small number of the insects in the fields which he had chosen for the experiments.

ADAMS FUND.

Project 3. Plant Lice Investigations. The major part of the work under this investigation has been carried on in the vicinity of Fort Collins, though it has been necessary to make numerous trips into different portions of the State, and Mr. Weldon has also given this project a considerable share of his time on the Western Slope, especially to the collecting and rearing of the plant lice. Mr. Urbahns, while employed by this section, gave much of his time to the rearing of the parasitic and predacious enemies of the plant lice. Miss Palmer, aside from making numerous drawings in color and also in ink, has devoted considerable time to the study of the life habits of a few of our more common species of lady beetles, and has obtained some very interesting results.

The plant lice more especially studied are the green apple aphis *(Aphis pomi)*, the woolly apple aphis *(Schizoneura lanigera)*, the melon louse *(Aphis gossypii)*, the green peach aphis *(Myzus persicae)* and the clover aphis *(Aphis bakeri)*.

In addition to the work upon the species above mentioned we have also collected extensively, taking species that might be found either upon cultivated or native plants or weeds. This work we have found very important, as we often come upon one of the well known pests of some cultivated plant that is spending a portion of its year upon some unexpected weed or cultivated plant.

As a result of the plant louse studies, Bulletins 133 and 134 have been published, as well as several articles of a more technical nature, in the entomological journals. The more we do on this project, the larger becomes the field for future study and experimentation. So we hope to continue it for some years to come.

SPECIAL FUND.

Project 4.—Codling Moth Investigations. Work was planned both for the eastern and western slope for the purpose of determining more fully some points in the insect's life habits, and more especially to determine the proportions of poison to use in arsenical sprays for the destruction of the larvae before they enter the apples. The object in this part of the work was to determine the smallest number of applications and the weakest strengths of poisons that could be successfully used for the purpose of avoiding unduly filling the soil witih arsenic. On account of the spring freezes, which practically destroyed all the fruit on the eastern slope and which destroyed a large portion of it upon the western slope, this project was seriously interfered with. Mr. Weldon, however, carried through a series of experiments at Paonia and has obtained very satisfactory results, which are given in his report of this year. The project should be continued another year and should be carried through upon a larger scale.

Project 6.—West Slope Field Work. This project was proposed for the purpose of covering the general work that would be done chiefly by Mr. Weldon in his efforts to instruct the fruit-growers as to the best methods of controlling their orchard pests. This work is detailed quite fully in Mr. Weldon's report for the year. The writer has also made several visits to the western slope for the purpose of advising in this work both with Mr. Weldon and Mr. Whipple and the horticultural inspectors. I believe that much benefit to the fruit-growers has been derived from this work and I think it very important that it should be continued for many years to come.

Very respectfully submitted,

C. P. GILLETTE.

SUMMARY OF ANNUAL REPORT OF FIELD ENTOMOLOGIST.

Delta, Colorado.

Introduction.

It was found necessary to confine the work, more or less, to certain orchards, and on that account not so many were visited as we would have liked. Some little hard feeling may have been occasioned because of certain orchards not having been visited. An orchard was always visited upon request of the owner, so if any one was neglected they alone deserve the brunt of blame.

GENERAL CONDITION OF ORCHARD WITH REFERENCE TO INSECT PESTS.

Improved methods of spraying are generally practiced.

Parasitic and predacious enemies have been doing good work in the orchards and their attack, along with ordinary care in spraying by the owner of fruit tracts, leaves little room to worry over future prospects in controlling insect pests.

It is true in Colorado, as elsewhere in fruit sections, that the grower of a few trees is more troubled with insect pests than the man with a commercial orchard. The latter, depending on his trees for a livelihood, realizes the necessity of proper care. There are many men who should be compelled to spray their trees.

There is probably no possibility of ever exterminating some of our more serious insect pests, but they can be kept in check, so that little harm will result from their attack.

DIFFERENT PHASES OF WORK UNDERTAKEN.

1. Examination of Orchards.
2. Study of Spraying Methods.
3. Experiments with Insecticides.
4. Insect Pests of Orchards.
5. Control, natural and artificial.
6. Hindrances to natural control.

EXAMINATION OF ORCHARDS.

In the neighborhood of 100 orchards were visited and general conditions noted. Any unusual conditions, whether caused by insects or otherwise were always studied, and visits to such orchards as had problems of a Horticultural nature were on different occasions made in company with Mr. Whipple, Field Horticulturist at Grand Junction.

STUDY OF SPRAYING METHODS.

Probably in no other fruit section is spraying so generally practiced, and with such good results.

Apples are secured from 95 to 99 per cent. free of worms, through the use of thorough spraying methods. Other pests are not seriously dreaded as a rule.

Arsenate of lead is almost exclusively used in controlling the codling moth.

On account of the Arsenical poisoning of trees care must be exercised in its future use.

There are at least four principal ways whereby good may be obtained. 1—Arsenate of lead must not be used in such large quantities. 2—Trees must not be sprayed more than twice in a season. 3—Nozzle must not be held so that spray will be directed at trunk and larger limbs which will carry it to the ground. 4—Spraying must be done thoroughly without allowing excessive drip from the trees.

Spraying for aphis is not attended with the same dangers that beset one in spraying for the codling moth. There are two sprays now more generally used than any others in the control of aphis, viz.: "Lime and sulphur" and "Black leaf." The former is an excellent dormant spray to kill the eggs of all kinds of aphis that lay them upon the trees, the latter will kill every aphid touched in spraying when used at a strength of 1-75.

Soluble oils, kerosene emulsion, whale oil soap, etc., are giving place to the above sprays.

More failures in controlling aphis are due to careless work than to all other causes.

INSECT PESTS OF ORCHARD TREES.

The following is a list of pests found on orchard trees the past summer: Peach twig borer (Anarsia lineatella), Grain aphis (Aphis avenea), Clover aphis (Aphis bakeri), Cherry aphis (Aphis cerasi), Sweet clover aphis (Aphis medicaginis), Black peach aphis (Aphis persicae niger), Green apple aphis (Aphis pomi), Howard scale (Aspidiotus howardi), Climbing cutworms, Codling moth (Codia pomonella), Mealy bugs (Dactylopius sp.), Cherry slug (Eriocampoides limacina), Lecanium scale (Eulecanium cerasifex), Peach scale (Eulecanium nigrofasciatum), Plum aphis (Hyalopteris arundinus), Red spiders (Tetranychussp), Green peach aphis (Myzus persicae), Snout beetles (Cleonus collaris), Pea aphis (Macrosiphum pisi), Woolly aphis (Schizoneura lanigera), Brown mite (Bryobia sp.).

CONTROL OF INSECT PESTS.

Natural control. Lace-winged flies, Syrphus flies, and Ladybird beetles, along with other predacious and parasitic enemies, did excellent work in controlling aphis in many orchards.

Artificial control. Spraying is the most important, and practically the only artificial method used. Careful attention to details, such as cleaning up rubbish, etc., is often a great help.

Barriers to control. Many parasites work on both Syrphus and Lace-winged flies. Spraying also kills many beneficial insects, but not in proportion to the number of destructive.

EXPERIMENTS.

First. Experiments to determine the least strength of the Arsenate of lead that can be used effectively, and with the least number of applications. Two strengths were used in the regular experiment, 2 pounds per 100 gallons and 3 pounds per 100 gallons. Eighty-five trees were sprayed with these strengths at an interval of eleven days. Part of the rest of the orchard was sprayed by the manager, with 4½ pounds per 100 gallons, making two applications. The second began ten days after the first. The rest of the orchard was sprayed with the same strength, but received a third spraying about thirty days after the first. The purpose of the first two sprayings was to fill the calyx cups. One spraying would have been as good as two, provided the blossoms had come out with a little more regularity.

Counts of 15,469 Ben Davis and Jonathan apples showed the following results:

2 pounds per 100 gallons, 85% free from worms.

3 pounds per 100 gallons, 88% free from worms.

4½ pounds per 100 gallons, two sprayings, 95% free from worms.

4½ per 100 gallons, three sprayings, 97% free from worms.

Check tree, Ben Davis, 70% free from worms.

Second. Experiments to determine the effect of the different sprays upon the eggs of the Green apple aphis.

This experiment is still under way and we do not feel justified in drawing any definite conclusion from the work already done.

Three. Experiments to determine the effect of the "Black leaf" upon Red spiders.

This experiment indicated that "Black leaf" is an effective remedy for these pests. It was not found to be effective, however, in killing the eggs at the strength tried, 1-65 to 1-70.

GEO. P. WELDON.

REPORT OF CHEMICAL SECTION.

To the Director:

I have the honor to report that during the period elapsing since our last published report the work of the chemical section has consisted of those lines of investigation which had previously received your approval.

The portions of these projects completed within this period have been presented in the bulletins offered for publication by this section, i. e., Bulletins 124, 125, 129, 131, 132 and 135.

Bulletins No. 124 and 125 present the results of our study of the composition and comparative values of some of our Colorado hays, i. e., alfalfa hay, timothy hay, native hay, corn fodder, sorghum and hay made from one of our native saltbushes, *Atriplex argentea*. Bulletin No. 129, by Mr. Alford, presents the results of our study of the commercial methods of extracting and purifying beeswax. No. 131 treats of the arsenical poisoning of fruit trees. No. 132 of the destruction of concrete by alkali or alkaline waters, and No. 135 presents those features of our study of the Australian saltbush, *Atriplex semibaccata*, as we deem of general interest and advantage to the people of our State, in particular to those who have taken up their residences in sections of the State where the sufficiency of the annual rainfall for the production of good crops is usually a little uncertain and where a forage plant which will produce a good yield with a small amount of water is desirable. This section has presented Bulletin No. 135, in the hope that it may prove of immediate value to such sections of our State, but it has a further object; it presents the cultural and general data concerning the hay made from this saltbush which serve as a basis for its further study on these lines presented in Bulletins 39 and 124. It bears the same relation to a bulletin which I shall present in the future that No. 93 presents to No. 124.

The arsenical poisoning of fruit trees and the destruction of concrete by "alkali" are special features of our alkali problem, but are of such considerable and immediate importance that I deemed it justifiable to present these subjects by themselves.

This section has begun no new work, because the subjects already approved engage our attention for some time to come.

The study of the Rio Grande and their relations of the San Luis Valley has been continued completed within the next year. The favorable for the prose-

cution of this work, owing to the exceptionally high water in the river. We were, at least, afraid to proceed with the work during this season, 1907, because we feared that the unusual amount of water in the river would obscure the factors which we wished to determine. It seems now that we might have proceeded with safety, but we did not know this at the time and it required considerable proof to convince us that such was really the case.

The study of the composition of fodders and their comparative values has been advanced since the publication of Bulletin No. 124, by the study of the Australian saltbush, atriplex semibaccata, on which the analytical work has been completed and will be ready for publication sometime during the coming summer.

The general problems of alkalies in Colorado is being studied concurrently with our other work, but I am desirous of bringing it to an end at the earliest possible date, which, however, I can not hope to do very soon.

The subject of mountain irrigation and the composition of the hay grown under this system combines two lines of work previously studied separately, i. e., the changes of the irrigation waters and the composition and comparative value of fodders. I hope to actively begin this work during the next irrigation season. While this work forms a single study it will evidently have to be treated from these two standpoints, which it may be advisable to treat separately, but this is a matter for further determination.

The work done on the study of the deterioration of manure under our Colorado conditions is being put into shape for publication by Mr. Douglass, but he is so continuously engaged in other work that it will be sometime before he can complete it.

The systematic work planned for this section is more than sufficient to keep all of its force busy for at least two years, so there is no opportunity for doing miscellaneous work, for which there continues to be many applications, especially for analyses of soils and waters. Sometimes these miscellaneous matters are of general interest and even important, but usually they are not.

The equipment and appointments of our laboratory are adequate to our present needs.

Respectfully submitted,

WM. P. HEADDEN.

Fort Collins, Colo., Nov. 1, 1908.

To the Director:

On account of the demands upon my time, with which you are familiar, my part in Experiment Station work has not been pushed so vigorously as I could have wished; however, some progress has been made. But in the subsection the usual good work has been accomplished, as the reports from the men will show.

Taking up the schedule of work as outlined last spring, we find the work in the following condition:

Red Raspberry Industry, not yet written up.

Tomato Blight. Good results in controlling this disease were secured by growing the plants in sterilized soil. Almost no blight appeared in plants so grown. Further experiments desirable.

Raspberry Yellows. Considerable laboratory work has been done with this disease; a fungus was isolated and inoculation experiments show that it is capable of attacking raspberry canes. Another season will be required in which to complete the work.

Pea Breeding. This work is finished so far as the present experiments are concerned. A variety of suitable size has been secured, but whether it will meet the requirements of the canner can only be determined by an extensive field test.

The subjects of The Orchard Plant; Location; Site and Soil, and History and Development of the Fruit Industry have been written.

The Cold Storage investigation with vegetables has just been started. Results will not be secured until late in the winter.

Bean Breeding experiments, by Mr. Paull, were satisfactorily begun, but several years must elapse before results are secured.

The Strawberry Industry has been written by Mr. Longyear and is about ready for publication. Mr. Longyear has spent much time in studying the cause of the so-called black root of the strawberry plant. A much longer time will be required to complete the work.

Mention has been made in former reports of a bacterial blight of alfalfa. Since alfalfa is the basis of Colorado agriculture, and this disease is becoming more and more of a menace, it was thought best to devote considerable energy to determining the nature of the disease and the method of control, if possible. Accordingly, a bacteriologist, Professor W. G. Sackett, formerly of the University of Chicago, was secured to take up this work under

the Adams fund. Mr. Sackett has already got the life history of the organism well in hand and is making rapid progress with the work.

The potato investigations are proceeding satisfactorily, and, as a direct result of this, the output of the State will be increased this year many carloads. The principal work with potatoes is along the line of building up a better and more stable class of varieties by seed selection, as well as the investigation of potato diseases.

The fruit investigations continue to be satisfactory to all concerned. Mr. Whipple has the practical subjects, as outlined in his schedule, written and about ready for publication. These are as follows: The Grape Industry; The Dewberry Industry; Grafting; Packing; Fruit Buds and Pruning Mature Trees.

Respectfully submitted,

W. PADDOCK.

ANNUAL REPORT OF THE FIELD HORTICULTURIST.

To The Director:

Report of the Field Horticulturist.

During the year a total of nearly seven weeks of my time has been devoted to extension work in different parts of the State, four weeks to Short Course work and three weeks to one-day summer meetings. The rest of my time has been given to special lines of work connected with this office, trips to other fruit districts of the State, and general field work. Much of the time, however, has been devoted to work in Mesa county.

The special lines of work outlined at the beginning of the year by Prof. Paddock and myself consisted of investigations and experimental work upon the following subjects:

Pruning Mature Fruit Trees, Picking and Packing Fruit, Top-Grafting, Dewberry Growing, Grape Growing, Root Rots of Fruit Trees, Crossing Fruits, Bloom Notes, and Fruit Buds and Fruit-Bearing Habits. In addition to this, some special work, of a nature that could not well be anticipated, has been taken up throughout the year. One of interest has been the effect of frost upon bloom and fruit and the value of second-crop bloom considered from the standpoint of fruit production. Another line of investigation has been the effect of whitewashing peach trees, in toto, as a means of retarding the blooming season.

The work along the line of pruning mature trees has been largely observations in the field, the effects of the different methods of pruning as practiced. The manuscript for a bulletin is now prepared.

The object of the work in picking and packing fruit is the preparation of a bulletin for the instruction of fruit growers in the best methods of picking and packing fruit. The information has been gathered by observations in the field, with suggestions for improvement on present methods gleaned from the experiences of other sections.

The manuscript for a bulletin upon top-working fruit trees has been prepared and is intended to give information as to methods of top-working and when it is advisable.

The work upon the subject of root rots has been practically dropped, as it appears to come under the work of the Department of Chemistry. There are cases where the death of roots is not due to arsenical poisoning, but they are scattered and probably result from a variety of causes.

The object of the work in crossing fruit has been to obtain crosses between our common varieties of apples and the seedless apple, in hopes of getting a seedless seedling of merit. No progress has been made on account of the late killing frosts of the past two seasons.

Notes have been gathered upon the blooming season of the different varieties of apple and pear, with a view of ascertaining which varieties are suitable for interplanting to secure cross-fertilization. The observations have shown considerable variation; even the blooming seasons of two varieties do not always bear the same relationship to each other in different seasons.

The dewberry industry has been studied in the best dewberry sections of the State, and the manuscript for a bulletin has been prepared upon the subject.

After a thorough study of the condition of the grape industry in the State the manuscript for a bulletin is now being prepared. Methods of handling vineyards are not well understood and it is hoped that the growers may be encouraged to use better methods in growing grapes, especially to adopt better methods of pruning.

The information gathered upon fruit-buds and fruit-bearing habits has been incorporated in the manuscript for the bulletin on pruning.

The experiments undertaken to demonstrate the value of white-washing peach trees as a means of prolonging the dormant season showed very little benefit derived from the treatment. The trees were retarded only slightly, if any.

Observations upon the effect of frost upon bloom and fruit and the value of second-crop bloom have been assembled in a manuscript for publication as a bulletin, if worthy, or to be kept as a matter of record.

Work spoken of as general field work consists of answering calls for information upon the care of particular orchards or to give solicited suggestions upon the treatment of the orchard to overcome difficulties.

Respectfully submitted,

O. B. WHIPPLE,
Field Horticulturist.

REPORT OF THE BACTERIOLOGIST.

1908.

Beginning with May 1, 1908, a new line of work was introduced into the Experiment Station. Previous to that time only a limited amount of investigation work along bacteriological lines had been carried on, and with the increasing importance of the subject and with the new problems which were continually arising, it seemed advisable to take up more extensive as well as intensive studies in this field. Accordingly a laboratory for bacteriological research was established under the Adams act. This laboratory has been fully equipped with the most modern appliances for accurate work and will be in perfect running order in the very near future. While considerable time has been consumed with the furnishing, equipping and arranging of these new quarters, we have, nevertheless, been able to carry on some investigation work at the same time. Unfortunately not much laboratory work was accomplished the first two months, owing to lack of equipment, but since then our undertakings have been more fruitful.

The most important problem which has claimed our attention is a bacterial disease of alfalfa. We have been able to isolate the causal organism and to reproduce the disease on alfalfa cuttings under laboratory conditions with a reasonable degree of certainty. While the stems inoculated with laboratory cultures resemble closely those found in the field, they do not have exactly the same appearance as those naturally infested. This is undoubtedly due to the difference in outdoor and laboratory conditions.

The morphological and cultural reactions of the organism are now being worked out for the purpose of identification, and during the winter season it is expected to continue the inoculations upon greenhouse material and in the spring to carry this phase of the work into the field. Field inoculations this season were impracticable, owing to the late date at which the causal organism was isolated.

Greenhouse experiments are now being carried on with the view to ascertaining, if possible, how the natural infection of the plants occurs. Next spring it is expected to spend a large amount of time in the field where the disease occurs naturally, with the purpose of studying further the methods of natural

infection as well as to test out the pure cultures of the organism isolated by inoculations under field conditions.

Of the twenty-six different varieties of alfalfa which were planted on infested land at Gypsum, Colorado, over a year ago, with the idea of obtaining, if possible, a disease resistant plant, there is one variety and possibly two which look very promising. This variety work will be continued another season, with the hope that we may be able to solve the economic side of this question in this manner. Respectfully submitted,

WALTER SACKETT,
Bacteriologist.

POTATO INVESTIGATIONS.

The work on the Colorado potato industry has been carried on during the past year along practically the same lines as the year previous.

Varieties of potatoes secured from the United States Department of Agriculture, with some others from this State, were again planted on the E. R. Bliss ranch, near Greeley. The object of growing these varieties at Greeley was partly to test them for yield and general desirability, as compared with the standard varieties grown there, and partly to secure, if possible, a variety that will be resistant to the soil diseases that frequently attack potatoes in this State. Notes were kept as to habit of growth, size of plant, time of maturity, yield, etc., as compared with the standard varieties.

Only a few of the seventy varieties have given promise of being able to compete with the "Pearl" as market varieties.

Very little trouble from the soil diseases was had with any of the varieties, so no data as to resistance were obtained.

A plot of about three acres of potatoes was grown on the College land at Fort Collins. In this field experiments with different treatments of seed potatoes, methods of preparing seed and cultural methods were conducted.

This field was also used for a study of the diseases and insect pests. So much time has been spent in promoting the industry and advising growers in other parts of the State that much systematic study of the diseases has not been possible.

The survey of the potato-growing districts of the State has been carried on for the most part in connection with the institute work. During the season visits have been made to the valleys of the Eagle, Crystal, Roaring Fork, Grand and Uncompahgre rivers, the San Luis valley and to La Plata and Montezuma counties.

In promoting the industry and instructing the growers in regard to varieties, cultural methods, etc., talks have been made at sixty-nine places since the previous report.

Probably the most important work is that being carried on in co-operation with the growers in various parts of the State. The aim in this is the improvement in yields and quality of potatoes from planting seed that has been hand selected in the field.

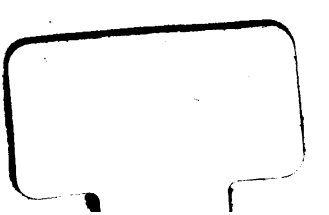
Colorado is producing as good, or better, quality of potatoes than any state in the United States. The yield per acre was greater last year (United States Department of Agriculture Statistics) than any state except Wyoming. The cost of produc-

tion per unit is less than in other states. There is sufficient undeveloped land in the State adapted to potato culture to produce three or four times the present total output. This year Colorado will produce about 20 per cent. more potatoes than previous years. The value will probably reach six million dollars, or about twice that of all the fruit of the State.

If the growth of the industry in the State continues normally, Colorado ought in a few years to be one of the leading potato producing states of America.

CABBAGE INVESTIGATIONS.

Along with the potato investigation at Greeley data have been secured on cabbage growing in Colorado. This data have been secured for the purpose of writing up the industry in bulletin form for the benefit of the new comers to the State.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

E. R. BENNETT.